Kok River Basin

Pilot Study for Water Resources and Environment Management (Basinwide)

7.1.25/97/UKM

Final Report

October 2000

Office of Environmental Policy and Planning, Thailand
Mekong River Commission

Kok River Basin -
Pilot Study for Water Resources
and Environment Management (Basinwide),
7.1.25/97/UKM

Final Report

13 October 2000

Office of Environmental Policy and Planning, Thailand

Mekong River Commission

Contents

Acronyms and abbreviations iv
Summary v

1 Introduction 1
2 The Kok River Basin 2
2.1 Overview 2
2.2 Water balance 5
2.3 Land use and environment 8
2.4 Population and domestic water supply 12
2.5 Sector studies 14
2.6 Administrative framework 18
2.7 Related development programmes 22
3 Development potential and development effects 25
3.1 External forces 25
3.2 Domestic demand 27
3.3 Sector development 27
3.4 Water availability 30
3.5 Environmental impact 34
3.6 Social impact 37
4 Integrated planning 38
4.1 Integrated planning versus sector planning 38
4.2 The Plan and the planning process 39
4.3 Integration of sector goals and strategies 42
4.4 The water resources dimension 43
4.5 The environmental dimension 44
4.6 The social dimension 44
5 Implementation 46
5.1 Goal formulation 46
5.2 Basin planning and national planning 47
5.3 Institutional arrangements 48
5.4 Stakeholder participation 51
5.5 Application of models 52
5.6 Projects 53
5.7 Monitoring 53
6 Management plans and guidelines 55
6.1 Purpose and contents of management plans and guidelines 55
6.2 Water pollution control 56
6.3 Solid waste management 58
6.4 Natural resources and environment conservation 59
6.5 Public awareness and public participation 62
Bibliography 64

Appendices

A Sub-basin summaries of water balance and demand A-1
B Resumes of thematic studies and sector studies B-1
C National planning goals and strategies C-1
D Glossary D-1
E Project ideas E-1

Tables

2.1 Sub-basins of Kok River Basin 2
2.2 The project area at a glance 4
2.3 Existing irrigation schemes in the project area 6
2.4 Alluvial soil areas 7
2.5 Present land use 9
2.6 Soil suitability for cultivation 9
2.7 Unit loadings of pollutants 11
2.8 Estimated loadings in 1998 12
2.9 Population in the project area 13
2.10 Present domestic water demand 14
2.11 Tourist arrivals and spenditure 17
2.12 Existing hydropower plants 17
2.13 Administrative units in Kok River Basin 19

3.1 Socio-economic imbalances 26
3.2 Future domestic water demand 27
3.3 Summary of water demand, consumption and impact 30
3.4 Capacity of proposed reservoirs 31
3.5 Estimated loadings in 2020 36

4.1 Context-related challenges 42
4.2 Process-related challenges 42
4.3 Challenges related to institutional capacity and information flow 42
4.4 Success criteria 42
4.5 Examples of inter-sectoral linkages 43

5.1 Scope of integrated management 46
5.2 Administrative levels of plan implementation 49
5.3 Draft Terms of Reference for a Kok River Basin Committee 50
5.4 Draft agenda for annual meeting of the Kok River Basin Committee 51
5.3 Models applied in the present study 52

Figures

2.1 Kok River Basin 3
2.2 Kok River flowing from Myanmar into Thailand 4
2.3 Average rainfall 5
2.4 Average runoff 5
2.5 Simplifed diagramme of the Chiang Rai Weir regulation 6
2.6 The Chiang Rai Weir 7
2.7 The Nile tilapia 16
2.8 Mae Mao dam 17
2.9 Outline of the national planning procedure 22

3.1 Location of planned reservoirs 31
3.2 Network diagram of present and future regulation 32
3.3 Sewage stabilisation ponds to serve Chiang Rai Town 35

4.1 Components of integrated planning 39
4.2 The planning cycle 40
4.3 Inputs and outputs of the planning process 41

6.1 The Kok-Mekong confluence 62

Acronyms and abbreviations

ADB	Asian Development Bank
ASP	Agricultural Sector Programme
BDP	The Basin Development Plan (of MRC)
BOD	Biochemical Oxygen Demand
DEDP	Department of Energy Development and Promotion
DEQP	Department of Environmental Quality Promotion
DF	Department of Fisheries
DFID	Department for International Development, United Kingdom Government
DLA	Department of Local Administration
DPC	Department of Pollution Control
EGAT	Electricity Generating Authority of Thailand
GIS	Geographical Information System
GMS	Greater Mekong Sub-region, *or*
	Greater Mekong Sub-region Initiative (or --- Programme)
GWP	Global Water Partnership
LDD	Land Development Department
MOSTE	Ministry of Science, Technology and Environment
MRC	Mekong River Commission
MRCS	Mekong River Commission Secretariat
NEB	National Environment Board
NESDB	National Economic and Social Development Board
NGO	Non-Governmental Organisation
OARD	Office of Accelerated Rural Development
OCRA	Office of Chiang Rai Administration
OEPP	Office of Environmental Policy and Planning
PEA	Provincial Electricity Authority
PIP	People's Irrigation Project
PWA	Provincial Waterworks Authority
PWD	Public Works Department
RDP	Rural Development Programme
RFD	Royal Forestry Department
RID	Royal Irrigation Department
SR	Study Report (prepared under the present project)
TDRI	Thailand Development Research Institute
TISTR	Thailand Institute for Scientific and Technological Research
TNMC	Thai National Mekong Committee
WUP	The Water Utilisation Programme (of MRC)

Summary

Study objectives

The study has two objectives. One is to produce a framework for integrated planning and management of water resources and the environment of the Kok River Basin. Another is to serve as a pilot study , from which experience can be drawn to similar integrated management studies and practices elsewhere in the Mekong Basin, as well as for the Basin as a whole.

Management basis

The development of Kok River Basin is exposed to several external driving forces. These are determinants, or causes in cause-effect relationships, which affect the Basin and its water resources, and thereby, directly or indirectly, the course of its development. Examples are population pressure; pressure from global and regional competition; increased demand of public services (like education and health care), and the associated need of funding; and increased energy prices.

Between them, these forces seem to point at three needs: (i) A need of change (or to adapt to changes); (ii) a need of higher product value per unit of water; and (iii) a need of sustainability.

Apart from the external forces, the development is determined by the demand and availability of raw water, various issues related to specific sectors, and environmental and social consequences of development. Some of the aspects can be controlled by management, while others cannot. Many of the opportunities and constraints will change with time. In other cases, our knowledge about them and the understanding of their significance will change with time.

Integrated management

Integrated management of water resources and the environment is directed towards the many inter-sectoral dependencies that may be less visible in each sector plan. Integrated management is well suited for steering the development clear of constraints, and, at best, to provide an added value to the sector plans by identifying options and opportunities that may have been overlooked because they relate to a combination of sectors rather than a single one.

Conceptually, the management can be regarded as three parallel processes, which are closely related and equally important: (i) Goal formulation; (ii) implementation; and (iii) knowledge-building.

Development objective

Management should build on a formulation and occasional re-formulation of *clear, agreed, long-term development objectives*. The formulation of such objectives is a process in itself. While they may be easy to draft in general terms, it may be time-consuming and intricate to achieve some practical extent of consensus about them among the stakeholders.

Once agreed on, the objectives can serve as the starting point for policy formulation and implementation. In this connection, the objectives can also serve as a reference for delegation of responsibility from the decision-makers to the specialists.

The following double development objective is tentatively suggested for management of water resources and the environment of Kok River Basin:

> *An allocation of water resources that is physically feasible, socio-economically suitable, and environmentally sustainable; and*
>
> *an environmental state of the Kok River Basin complying with standards that have been agreed between the stakeholders.*

Natural resources and ecosystems

The Kok River Basin is characterised by stressed ecosystems, distorted water yields caused by deforestation, soil erosion, landslides and downstream sedimentation, and, in turn, reduced soil fertility caused by soil erosion and leaching of nutrients. Visible effects are lack of water in the dry season, lowering of the groundwater table, and increased floods in the rainy season.

The major part of the project area is influenced by human activities. This is obviously the case for the agricultural farmlands, but even the upland forest areas largely appear as disturbed, encroached, partly cultivated, or recently re-planted. The forests have been under strong pressure for many decades, being felled for timber and for expansion of agricultural land. Today, the status of remaining forests is at 'caution level'

Public water supply

There are two large waterworks in the Basin, operated by PWA: Chiang Rai and Fang. Another PWA plant is under construction in Chai Prakarn. Elsewhere, the domestic demand is served by small-scale facilities or individual withdrawals, based on either surface water or groundwater. The total present demand for domestic supplies (in the entire Basin) is around 2 m3/s. The corresponding return flows are estimated at 80 percent.

Groundwater

While the surface water resources are fully utilised, the groundwater resources (if they exist) are almost undeveloped. This offer a particular opportunity for regulation of groundwater abstraction. Well yields are generally characterised as 'high', and no shortages have been reported. There is no information available about the size and distribution of the groundwater resources.

Groundwater management must involve *effective prevention of contamination.* This comprises (1) good practices for use of pesticides and fertilisers, including a ban on the most severe contaminants; (2) retention of all toxic compounds at the point of origin; and (3) disposal of solid waste by means that prevent contamination by infiltration.

Irrigation

Today and in the future, the agricultural sector is by far the largest water consumer in the basin. Existing irrigation schemes cover a total area of 675,460 rai (1081 km2). The schemes are either diversion schemes or pump irrigation schemes. All are based on surface water.

There are eight planned reservoirs in the Fang, Upper Lao and Suai sub-basins. They will control some 20 percent of the Fang sub-basin, some 26 percent of Upper Lao sub-basin, and nearly all of the Suai sub-basin. In total, they will generate an irrigable area of 205,000 rai. This is an expansion by 30 percent of the area that is irrigable today. The effective impact is larger, because the scarcity of water implies that not all the irrigation project areas can actually be irrigated, particularly in the dry season. It is expected that the actually irrigated areas will increase by 55 percent and 33 percent in the dry and the wet season, respectively. The Nawang Reservoir has the important side objective to serve the domestic demand in Fang District.

There is a need of rehabilitation or upgrading of some of the existing schemes, in order to improve their water efficiency. There is also scope for non-structural development measures, like improvement of irrigation management and field application efficiencies. It is evaluated that such measures can improve the water efficiency from 30 percent today to 40 percent in the future. This makes it possible to increase the irrigable area by 10 and 7 percent in the wet and the dry season, respectively. This improvement can be achieved at little or no environmental cost.

Hydropower

There are three mini-hydropower plants in the project area. All are located in the Fang sub-basin. Their joint capacity is 8.7 MW, and their joint yield is 30 GW-hours per year.

Two hydropower schemes are planned: (1) Nam Kok hydropower project (in Myanmar) (storage volume 3,033 Mm3); and (2) Upper Fang multi-purpose project. If the Nam Kok project is implemented, it will cause a general, positive change in the water availability in the Upper and Lower Kok sub-basins. There is scope for an additional (although moderate) development of hydropower in connection with some of the planned irrigation reservoirs. If energy prices will escalate over the next decades, there will be a strong motivation to implement schemes that are feasible or nearly feasible with today's cost-benefit ratio.

Forestry

Since 1989, there has been no commercial forestry in the project area, in spite of forests covering 47 percent of its area. This is because the forest areas are now in a state of restoration, following over-exploitation in the past. The restoration process is supported by a general ban on logging.

In the long term, there is a clear scope for commercial forestry. Once restored, and with proper management, a part of the forest area will become an important commercial asset.

Separate goals must be pursued for upland agro-forestry cultivation. The mountainous forest ecosystems are fragile and under pressure. Agro-forestry is an option for sustaining the upland and mountainous ecosystems, while, at the same time, stabilising the living conditions of the farmers. Management options comprise (i) stabilisation of sloping areas; (ii) maintenance and improvement of the soil fertility; and (iii) improvement of the microclimate. In the medium term, in order to prevent stagnation and marginalisation, additional sources of income must be sought as a supplement to subsistence cultivation.

Wetlands

The two major wetlands in the project area are Nong Luang and Nong Wiang. Both are partly regulated by structures, and are fairly influenced by human settling and utilisation. Their ecosystems and biodiversity are not well known. Both areas are used as water sources and for fishing. Some informal restrictions on fishing and hunting have been self-imposed by the local communities.

Fisheries

More than a hundred fish species are reported in the project area, including several economic species. Some species migrate between the Mekong and the Kok River Basin, where they breed. The yield is relatively low. The standing stock is estimated at 3-4 kg/rai, which is well below the national average of 15 kg/rai. Fishing is mainly practised for own consumption.

Development of capture fisheries must aim at *(1) preservation of biodiversity and habitats (including water quality, important migration routes and breeding grounds), and (2) prevention of over-exploitation.* The potential for commercial development is small, but the possibility exists of increasing the yield from capture fisheries in (present and future) reservoirs. A particular concern is the risk of contamination of edible fish by pesticides.

Tourism

The tourism sector appears as an attractive option for economic development in the medium term, and, in case of prudent management, in the long term as well. The development should aim at *higher earnings per day spent by tourists, minimising the environmental and social impact, and maximising the socio-economic benefits.*

Surface water quality

The water quality and the aquatic ecosystems are exposed to the combined effects of two threats: (i) The risk of a reduced streamflow in the dry season, caused by the increased demand of water; and (ii) the risk of an increased pollution load, caused by population growth, changed lifestyles, intensified tourism, and intensified agricultural and industrial production.

Today, there are no sewered areas at all in the basin, and no treatment plants have been established. Sewage stabilisation ponds are under construction to serve Chiang Rai Town.

Industries are typically processing plants for fruits and vegetables, or noodle factories. They produce mainly organic sewage. Most industries are located around Chiang Rai, and in the Fang and Upper Lao sub-basins.

No information is available about loadings other than BOD, nutrients and bacteria. It is not known whether heavy metals, chlorinated hydrocarbons and other serious pollutants are released to the environment within the project area.

Loadings from agriculture are influenced by (i) a prudent use of pesticides (including types of pesticides, and application practices); and (ii) appropriate land use management, aiming at protection of headwaters, and prevention of widespread soil erosion. Loadings from industries and hospitals (other than BOD and nutrients) should be controlled at the source.

The rivers do not seem to be exposed much beyond their assimilative capacity in terms of BOD, nutrients or bacteria, although increased levels have been measured at places. There is a fair diversity of fishes, vegetation, plankton and invertebrates. Only a few measurements have been made of pesticides in the aquatic environment, and no information is available about contamination of fish caught in the rivers.

Solid waste

In general, the disposal of solid waste is under pressure, because the quantities escalate due to urbanisation and changed lifestyles. At the same time, disposal practices are not in place, or disposal routines and facilities (like incinerators) are in need of upgrading or restoration.

Domestic waste and toxic, infectious or otherwise hazardous waste impose different pollution risks and disposal requirements. The two categories should be segregated at the source and handled separately.

Management should include non-structural measures. The public should be encouraged to Reduce, Reuse, Recycle and Repair the waste. In this connection, economic incentives (fees and subsidies) may be considered.

Stakeholder participation

A precondition for successful management is a joint orientation among stakeholders, including consensus on sector objectives and strategies, and acceptance of rules and/or practices for water sharing and water quality.

This requires in turn (i) Added value of integrated management (as compared with sector planning); (ii) active participation by stakeholders in goal formulation and plan implementation; (iii) balance between stakeholder interests; and (iv) adequate information flow.

During plan formulation, stakeholder participation can be achieved at four stages that represent progressive levels of interaction: (i) Information gathering; (ii) information dissemination; (iii) consultations; and (iv) endorsement.

The process should proceed through the public representative institutions (the provincial governments and the tambons). The active involvement of these institutions is a mutual advantage that can strengthen the institutions and the planning process at the same time. In many cases, NGOs are in a particular position to supply knowledge and experience about concerns, priorities and constraints that can affect implementation of the various policies.

Supportive projects

A positive development can be promoted by interaction with relevant projects for awareness-building, generation of knowledge, or pilot implementation of new technologies.

These pilot projects have two objectives. One is direct, namely to support achievement of the development goals. The other is indirect, namely to sustain and enforce the development process as such, by making it visible and attractive.

Examples of such projects are listed in Appendix E. Once identified, they may be funded from a variety of sources, and implemented by a variety of agencies and organisations, including the private sector.

Monitoring

Monitoring is required in order to keep the development on the right track. Apart from changes brought about by the plan implementation, numerous other changes will appear. These can affect both the validity of the development objectives, the various sector goals, the supplies, the demands, and the consequences of different courses of action. Even if there were no changes at all, an improved knowledge can in itself put the planning in a new perspective.

A substantial monitoring is in progress today under various authorities. In some respects, however, the monitoring is incomplete. For example, little is known today about groundwater availability or groundwater quality.

An important objective of the monitoring is to extend the knowledge base for over-all system descriptions like the ones prepared in connection with the present project. Better knowledge will allow for more accurate estimates of (for example) the availability of groundwater, or the ecological demand of surface water. This will in turn improve the analysis of various strategies for water allocation.

Another important objective is an early identification of threats, while there is still scope for mitigation, or of new opportunities, while they still exist.

1

Introduction

Reference

The *Pilot Study for Water Resources and Environment Management (Basinwide)* was initiated in July 1998 by the Mekong River Commission Secretariat (MRCS). It was completed in October, 2000. Findings were reviewed at a Steering Committee meeting on 4 October, 2000, and a regional seminar in Chiang Rai on 9-10 October, 2000.

The study was executed by Office of Environmental Policy and Planning (OEPP), Ministry of Science, Technology and Environment (MOSTE), of the Government of Thailand. Specialist services for the study were provided by ASDECON. Funding was granted by Department for International Development, United Kingdom (DFID).

The progress was guided by a Steering Committee with participation by OEPP, MRCS, the Thai National Mekong Committee (TNMC), Royal Irrigation Department (RID), Royal Forestry Department (RFD), and Office of Chiang Rai Administration.

Objectives

The study has two objectives. One is to produce a framework for integrated planning and management of water resources and the environment of the Kok River Basin. Another is to serve as a pilot study , from which experience can be drawn to similar integrated management studies and practices elsewhere in the Mekong Basin, as well as for the Basin as a whole.

Sector studies and thematic studies

Several sector studies and thematic studies were made of the Kok River Basin in connection with the project. The findings of these studies are described in a series of study reports (SRs):

SR-1	*Water resources*
SR-2	*Rainfall-runoff modelling*
SR-3	*Water resources modelling*
SR-4	*Water pollution*
SR-5	*Pollution load modelling*
SR-6	*Watershed management*
SR-7	*Land use*
SR-8	*Agriculture*
SR-9	*Fisheries*
SR-10	*Solid waste*
SR-11	*Aquatic ecology*
SR-12	*Socio-economics*
SR-13	*Community participation*

These studies provide an important part of the basis for the integrated planning.

2

The Kok River Basin

This chapter describes the starting point for the planning and management process: The Basin as it appears today, with its water resources, land use and environment, socio-economics, and the various economic sectors. Furthermore, an outline is given of the administrative framework, and of projects and programmes that are intended (or expected) to influence the development of the Basin.

2.1 Overview

Kok River Basin is a part of the 795,000 km2 Mekong River Basin. It lies partly in Thailand (68 percent) and partly in Myanmar (32 percent). The project area for the present study is the Thai part of the basin. The Myanmar sub-basin have been included in the hydrological studies, so that water balances and related analyses cover the entire basin.

The project area is shown in Figure 2.1. Key figures of the sub-basins are given in Table 2.1. Please refer to Appendix A for summary information about present and future conditions in each sub-basin.

Sub-basin	**Main river length**	**Area**	**Area** in percent of basin area
Myanmar	180 km	3,363 km2	32 %
Upper Kok	62 km	931 km2	9 %
Lower Kok	84 km	1,205 km2	11 %
Fang	117 km	1,920 km2	18 %
Upper Lao	111 km	2,091 km2	20 %
Lower Lao	80 km	618 km2	6 %
Suai	50 km	437 km2	4 %
TOTAL	684 km	10,565 km2	100 %

Table 2.1: Sub-basins of Kok River Basin

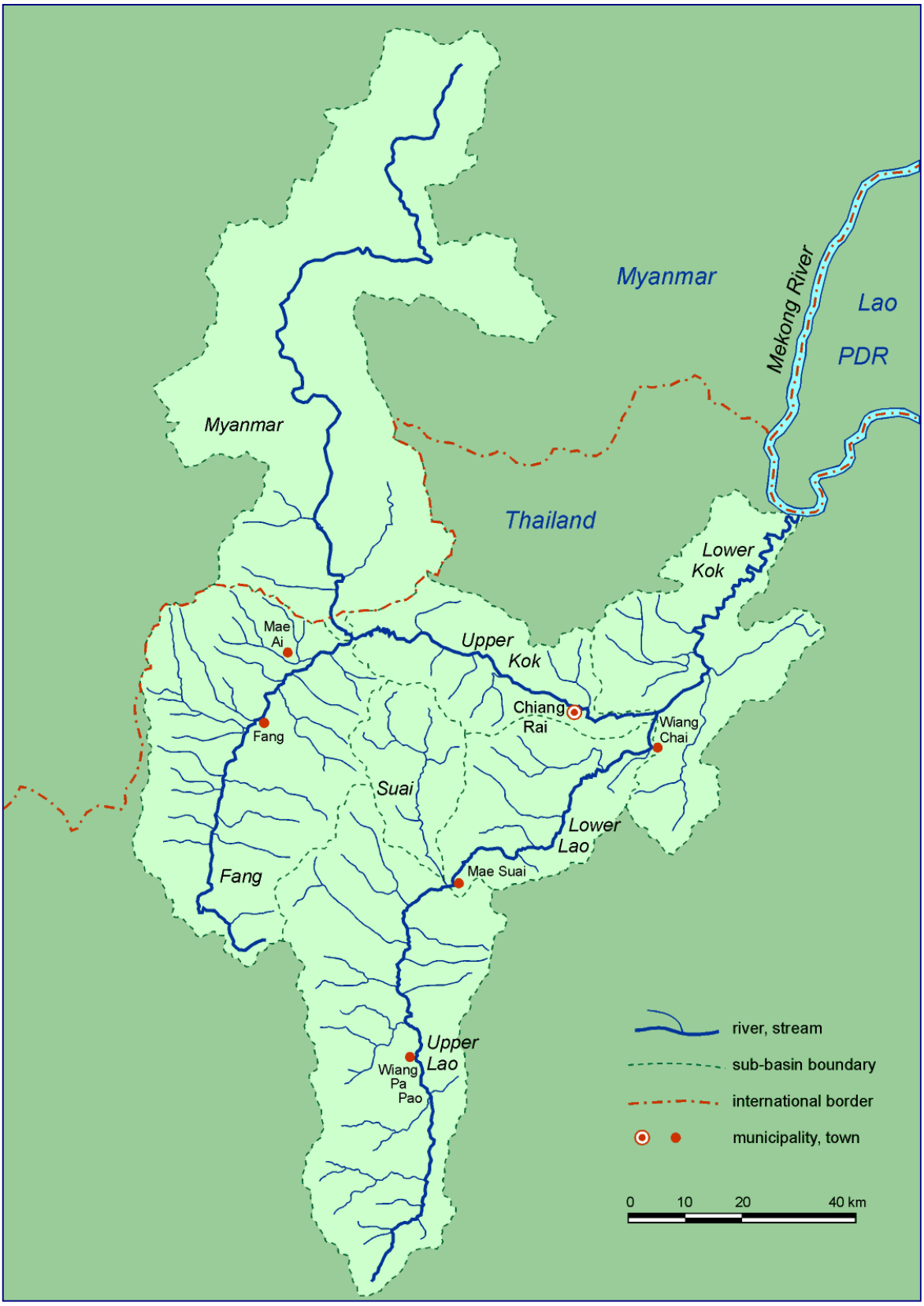


Figure 2.1: Kok River Basin

Figure 2.2: Kok River flowing from Myanmar (in the background) into Thailand (in the foreground)

The basin is mountainous, with elevations up to 2,300 m above sea level. Around 65 percent of the project area is classified as not suited for paddy nor upland crops, due to steep slopes. Still, some 46 percent of the area is cultivated, by irrigation (15 percent) or rainfed (31 percent). The climate is monsoon climate, with a pronounced seasonal variation of rainfall and streamflow. Some key figures are given in Table 2.2.

Area	7,175 km2 (project area) + 3,390 km2 (Myanmar part) = 10,565 km2 (total, Kok River Basin))
Present area distribution (in percent of project area, excluding Myanmar))	Irrigated: 15 percent rainfed: 31 percent forest, forest plantation 47 percent water and wetlands 2 percent others 5 percent
Population :	680,250 persons (1997), 1,674,000 (2020)
Largest town: Chiang Rai	52,952 persons (1997)
Household size :	4.1 persons/ household (1996 average)
Annual rainfall	1447 mm (1976-97 average)
Average discharge into the Mekong River	5294 Mm3/year (168 m3/s) (1971-87)

Table 2.2: The project area at a glance

2.2 Water balance

Below is given a short outline of the hydrological conditions. Summaries of the water balance for each sub-basin are presented in Appendix A. A comprehensive assessment of the present and future water resources is given in SR-1 (Water resources). Additional details are reported in SR-2 (Rainfall-runoff modelling) and SR-3 (Water resources modelling).

Rainfall and surface water

The seasonal rainfall variation is shown in Figure 2.3. It shows the typical monsoon pattern, with two peaks, one in the pre-monsoon period (May), and one during the monsoon proper (August). The driest month (in terms of rainfall) is January.

The streamflow variation is illustrated in Figure 2.4, which shows the discharge at a location in the lowermost part of Kok River, covering almost the entire basin. The driest month in terms of runoff is April.

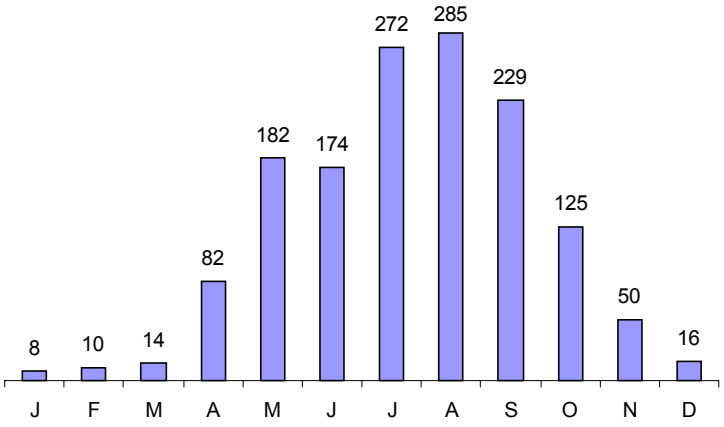


Figure 2.3: Average rainfall (mm/month)

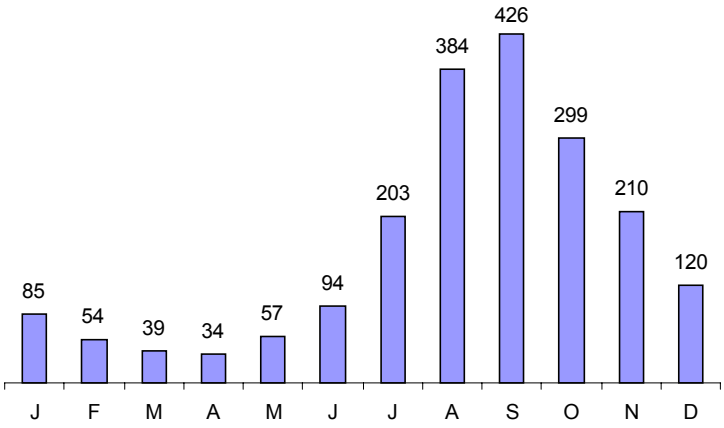


Figure 2.4: Average runoff (m3/s, at catchment area 10,300 km2)

Regulation and irrigation

Existing irrigation schemes cover a total area of 675,460 rai (1081 km2) (Table 2.3). The schemes are either diversion schemes or pump irrigation schemes. All are based on surface water. Some of them are in need of rehabilitation.

Today, there is one reservoir in the project area, the Nam Mae Mao hydropower scheme in Fang District. The catchment area is 61 km2, and the storage volume is 20.6 Mm3. The minimum release is estimated at 1 m3/s. The water is diverted along the River Mao for irrigation of orchards and farmland (SR-3, p. 4).

The Chiang Rai Weir project is intended for maintaining the navigational depth for tourist boating. Its catchment area is 6,220 km2, and its channel storage capacity is 1.3 Mm3. Apart from increasing the navigational depth, the project serves an irrigation area of 70,700 rai (113 km2) and 35,350 rai (57 km2) in the wet and dry season, respectively (SR-1, p. 16). The conveyance system for irrigation has just recently been completed.

Authority/project	**Fang River**		**Lao River**		**Kok River**		**TOTAL**	
	No.	Area (rai)	No.	Area (rai)	No.	Area (rai)	No.	Area (rai)
RID			1					
Large scale irrigation project			2	172,300			1	172,300
Medium scale irrigation projects	4	26,275	19	49,400			6	75,675
Small scale irrigation projects	43	100,665		45,750	22	54,000	84	200,415
OARD	1	750	3	11,325			4	12,075
DEDP								
Large scale irrigation project					1	78,000	1	78,000
Medium scale irrigation projects	1	16,000					1	16,000
Pump irrigation projects	3	12,600	2	2,200	13	34,100	18	48,900
DLC								
People's Irrigation Project (PIP)	47	13,919	27	30,890	38	27,286	112	72,095
TOTAL	99	170,209	54	311,865	74	193,386	227	675,460
1 rai = 0.16 ha = 0.0016 km2								

Table 2.3: Existing irrigation schemes in the project area (SR-1, p. 15)

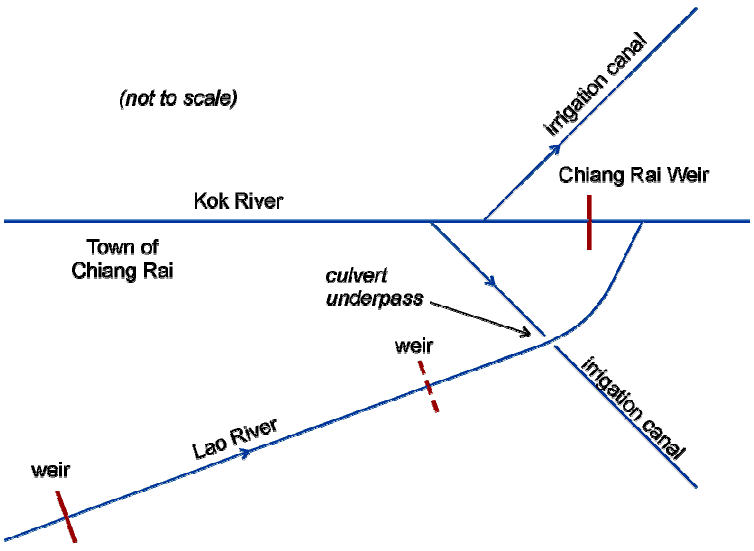


Figure 2.5: Simplified diagram of the Chiang Rai Weir regulation

Figure 2.6: The Chiang Rai Weir

Groundwater

Today, groundwater is extracted for domestic and industrial supplies. Hand pump wells for domestic supplies in rural areas have been established in many places by OARD, PWD and Department of Mineral Resources. Typical depths range between 20 and 80 m, with yields ranging between 2 and 18 m3/hour. Apart from many small industries, 10 larger industries (producing canned or pickled fruit and vegetables) operate their own groundwater wells.

The supply to the town of Chiang Rai is based on surface water.

Groundwater yields are generally characterised as 'high', and no shortages have been reported. There is no information available about the size and distribution of the groundwater resources. The extent of alluvial soils in the area (listed in Table 2.4) may serve as a rough, indirect indication of the potential.

Sub-basin	**Alluvial soils**	
	Area	percent of total area
Fang	128 km2	6.7 %
Upper Lao	91 km2	4.4 %
Lower Lao	4 km2	3.8 %
Suai	0 km2	0.0 %
Upper Kok	41 km2	4.4 %
Lower Kok	216 km2	18.0 %
TOTAL	479 km2	7.2 %

Table 2.4: Alluvial soil areas (SR-7, pp. 4-7)

2.3 Land use and environment

Land use

The present land use in the basin is shown in Table 2.5. This table is based on satellite imagery from March 1998. Please refer to SR-7 for details about the analysis.

The entries in Table 2.5 represent the following characteristics:

Paddy fields are located on the floodplain and on low terraces along the rivers. Glutinous rice is grown on 75 percent and 30 percent of the area in the wet and the dry season, respectively. The rest of the area is for non-glutinous rice

Upland crops are cultivated on middle and high terraces and hilly areas. Typical crops are maize, soybean, ginger, garlic, shallot and cabbage

Fruit trees are grown both on low and high lands. Typical crops are mango, longan and lychee

Wetlands are low areas that are flooded in part or all of the year

Forests comprise undisturbed primary forest, typically teakwood, and undisturbed secondary forest, typically bamboo. Forests also comprise other kinds of secondary forest on areas where timber logging took place in the past, and on slash-and-burn cultivation areas

Disturbed forests are forests that are partly felled to give place for upland crops (for example ginger or cabbage), or fruit trees

Forest plantations are areas that are in a process of rehabilitation under RFD programmes. The typical species is teakwood

	Myanmar	Fang	Upper Lao	Lower Lao	Suai	Upper Kok	Lower Kok	TOTAL
	km2	km2	km2	km2	km2	km2	km2	km2
1 Paddy field (irrigated)		289	158	172	2	61	410	1092
2 Upland crops (irrigated)		17	15	10		13	10	64
3 Fruit trees (irrigated)		5	9	3		7	17	41
4 Paddy field (rainfed)	41		1	1		1	2	45
5 Upland crops (rainfed)		487	521	160	238	389	380	2176
6 Fruit trees (rainfed)		13	2	3		1	12	30
7 Wetland		2					44	47
8 Forest	3239	878	1161	146	166	258	114	5962
9 Disturbed forest	111	84	110	25	8	68	23	428
10 Forest plantation		60	61	39	19	86	59	323
11 Urban/industrial/institution		2	4	21		9	47	83
12 Village area		45	33	29	2	23	58	190
13 Water body		2	3	6		8	19	39
14 Idle land		28	6	2		3	7	45
TOTAL	3390	1910	2084	616	436	927	1201	10565

	pct.	pct.	pct.	pct.	pct.	pct.	pct.	pct.
1 Paddy field (irrigated)		2.7	1.5	1.6		0.6	3.9	10.3
2 Upland crops (irrigated)		0.2	0.1	0.1		0.1	0.1	0.6
3 Fruit trees (irrigated)			0.1			0.1	0.2	0.4
4 Paddy field (rainfed)	0.4							0.4
5 Upland crops (rainfed)		4.6	4.9	1.5	2.3	3.7	3.6	20.6
6 Fruit trees (rainfed)		0.1					0.1	0.3
7 Wetland							0.4	0.4
8 Forest	30.7	8.3	11.0	1.4	1.6	2.4	1.1	56.4
9 Disturbed forest	1.0	0.8	1.0	0.2	0.1	0.6	0.2	4.1
10 Forest plantation		0.6	0.6	0.4	0.2	0.8	0.6	3.1
11 Urban/industrial/institution				0.2		0.1	0.4	0.8
12 Village area		0.4	0.3	0.3		0.2	0.6	1.8
13 Water body				0.1		0.1	0.2	0.4
14 Idle land		0.3	0.1				0.1	0.4
TOTAL	32.1	18.1	19.7	5.8	4.1	8.8	11.4	100.0

Table 2.5: Present land use (after SR-7, p. 14)

The soil suitability for cultivation of paddy or upland crops has been classified on the basis of the topography (i.e. the slope of the land) and the soil type (SR-7, p. 1). The distribution is shown in Table 2.6.

	Fang		Upper Lao		Lower Lao		Suai		Upper Kok		Lower Kok		TOTAL	
	km2	pct	km2	pct	km2	pct	km2	pct	km2	pct	km2	pct	km2	pct
Sub-basin area	1910	100	2084	100	616	100	436	100	927	100	1201	100	7175	100
Suited/moderately suited for paddy cultivation	210	11	104	5	277	45	0		83	9	517	43	1192	17
Moderately/poorly suited for upland crops	497	26	271	13	136	22	0		74	8	420	35	1398	19
Not suited, but in practise still used for upland crops and tree crops	1204	63	1709	82	203	33	436	100	770	83	264	22	4586	64

Table 2.6: Soil suitability for cultivation (SR-7, pp. 3-10)

Ecology

The major part of the project area is influenced by human activities. This is obviously the case for the agricultural farmlands, but even the upland forest areas largely appear as disturbed, encroached, partly cultivated, or recently re-planted. The forests have been under strong pressure for many decades, being felled for timber and for expansion of agricultural land. Today, the status of remaining forests is at 'caution level' (SR-6, p. 8).

The environmental state of the river system is described in SR-4, SR-5 and SR-11. Today, the rivers do not seem to be exposed much beyond their assimilative capacity in terms of BOD, nutrients or bacteria, although increased levels have been measured at places (SR-4, pp. 41-70). BOD levels are high in the dry season, whereas E. Coli concentrations are high in the wet season. There is a fair diversity of fishes, vegetation, plankton and invertebrates, and the fisheries yield is fair (SR-9).

Only a few measurements have been made of pesticides in the aquatic environment (SR-4, p. 65), and no information is available about contamination of fish caught in the rivers. Studies elsewhere in the Mekong Basin (reported by MRCS) *'... have shown that all fish sampled from rivers, wetlands and reservoirs throughout the region contain residues of pesticides which originate mainly from agricultural applications. The majority ... were below the maximum allowable concentration ... but this is likely to worsen in the future due to the rapid increase in pesticide use ... Compounds detected include DDT, dieldrin, heptachlor, endrin, lindane, parathion and organophosphates.'* (Quoted from *'Agriculture and Irrigation Programme for Co-operation Towards Sustainable Development of the Lower Mekong Basin', MRCS, November 1998).*

The major wetlands in the project area are Nong Luang and Nong Wiang. All are partly regulated by structures, and are fairly influenced by human settling and utilisation. Their ecosystems and biodiversity are not well known. The areas are used as water sources and for fishing. Some informal restrictions on fishing and hunting have been self-imposed by the local communities (SR-11, p. 24).

The Kok-Mekong confluence forms a wetland of some 5 km2.

Just north of the project area, near the Kok-Mekong confluence, is the Nong Bong Kai (or Chiang Saen Lake), were 121 bird species and 143 fish species have been recorded in the past.

Nong Luang

In 1986, RFD launched the Thailand Wetland Inventory Project, supported by IUCN (International Union for Conservation of Nature and Natural Resources), ICBPC (International Council for Bird Preservation), IWRB (International Waterfoul and Wetland Research Bureau), and WWF (World Wide Fund for Nature).

Nong Luang is one among 42 wetlands in Thailand that are listed in the National Wetland Inventory. The area used to be a habitat of waterfoul and aquatic weeds. There are also human activities around Nong Luang, such as fishery, aquaculture, farming (livestock) , and agriculture. In the dry season, Nong Luang is rather shallow, and its surface area is 350 rai only.

At present (1997), the biodiversity is low, both for the terrestrial ecosystems (forest and wildlife) and the aquatic ecosystem (plankton, benthos, fish and weeds). 4 bird species and 25 fish species have been registered. Pump irrigation is planned for an area of 9,000 rai. Reasons for the degradation are (i) siltation; and (ii) excessive waterlevel variations (flooding in the wet season, lack of drainage, and water shortage in the dry season).

Pollution sources

Present and future pollution sources are described in SR-4 and SR-5. A distinction is made between point sources and non-point sources. Point sources are domestic loadings, industries, and livestock.

They are specified as mass per unit per year. Non-point sources are diffuse loadings on a unit area basis, depending on the land use. They are specified as nominal concentrations.

The applied categories and unit contributions are shown in Table 2.7. The actual loadings will vary from place to place and from one season to another, depending on the sewage disposal, the applied agricultural practices, and other aspects.

Today, there are no sewered areas at all in the basin, and no treatment plants have been established (SR-4, pp. 2-3). A series of sewage stabilisation ponds is under construction (Figure 3.3), to serve the town of Chiang Rai.

Industries are typically processing plants for fruits and vegetables, or noodle factories. They produce mainly organic sewage. Most industries are located around Chiang Rai, and in the Fang and Upper Lao sub-basins.

A gross budget for each sub-basin for present BOD and nutrient loadings is shown in Table 2.8.

Source	**unit**	**BOD**	**Tot-N**	**Tot-P**
Domestic & small industries				
Non-sewered	kg/person/year	6.9	1.2	0.3
Sewered	kg/person/year	8.4	2.9	0.6
Treatment reduction	percent	20	50	80
Industrial increment	percent	30	5	15
Major industries		(individual estimates)		
Livestock				
Swine	kg/animal/year	11.7	7.6	1.3
Cattle	kg/animal/year	28.5	12.1	0.6
Fowl	kg/animal/year	0.7	0.2	0.2
Non-point sources				
Agriculture	mg/l	3.8	2.7	0.4
Orchard	mg/l	3.8	2.1	0.1
Forest	mg/l	6.0	0.8	0.06
Wetlands	mg/l	6.0	0.8	0.06
Urban	mg/l	10.6	2.2	0.5
Village	mg/l	4.4	1.8	0.2
Water body	mg/l	0.0	0.0	0.0
Barren	mg/l	13.0	5.2	0.6
	BOD:	Biological oxygen demand		
	Tot-N:	Total nitrogen		
	Tot-P:	Total phosphorus		

Table 2.7: Unit loadings of pollutants

		Myanmar	Fang	Upper Lao	Lower Lao	Suai	Upper Kok	Lower Kok	TOTAL
Area (total 10565 km2)	km2	3390	1910	2084	616	436	927	1201	10565
Nominal runoff	mm/year	890	587	335	632	581	804	833	684
Nominal runoff	Mm3/year	3017	1121	698	389	253	746	1001	7226
BOD									
Domestic	t/year	617	1,180	1,084	753	229	1,180	1,383	6,944
Industry	t/year	0	2	5	-	0	2	0	12
Livestock	t/year	325	545	425	995	107	545	1,391	3,908
Non-point sources	t/year	17,795	3,641	3,687	1,789	1,219	3,641	4,564	38,485
BOD, total	t/year	18,737	5,368	5,202	3,537	1,554	5,368	7,339	49,350
Tot-N									
Domestic	t/year	89	169	156	108	33	169	198	994
Industry	t/year	0	0	0	0	0	-	0	-
Livestock	t/year	157	264	193	459	46	264	638	1,809
Non-point sources	t/year	2,539	1,353	1,038	705	472	1,353	2,214	10,230
Tot-N, total	t/year	2,785	1,786	1,387	1,272	551	1,786	3,050	13,053
Tot-P									
Domestic	t/year	21	40	38	26	8	40	48	238
Industry	t/year	0	0	0	0	0	0	0	0
Livestock	t/year	37	80	77	185	23	80	251	674
Non-point sources	t/year	192	186	129	100	66	186	327	1,249
Tot-P, total	t/year	249	306	244	311	97	306	626	2,162

Table 2.8: Estimated loadings in 1998

Solid waste

The present and future disposal of solid waste is analysed and reported in SR-10.

The total production of solid waste in the project area (in 1996) is estimated at 32,800 t/year. The highest contributions are from Chiang Rai (14,200 t/year, or 43 percent) and Chai Prakarn (3,700 t/year, or 11 percent). In addition, around 230 t/year of infectious waste is estimated to be produced by the 457 hospitals and clinics in the project area (SR-10, p. 3).

In general, the disposal of solid waste is under pressure, because the quantities escalate due to urbanisation and changed lifestyles. At the same time, disposal practices are not in place, or disposal routines and facilities (like incinerators) are in need of upgrading or restoration.

Today, waste disposal sites are located far from streams and rivers, and are not expected to cause any significant pollution of surface waters (SR-4, p. 2). In general, however, the risk must be kept in mind that waste disposal sites can contaminate the groundwater by seepage of toxic compounds.

2.4 Population and domestic water supply

Population

The project area comprises parts of 2 provinces: Chiang Rai and Chiang Mai. In the Chiang Rai part of the Basin, there are 11 districts, 56 sub-districts and 570 villages. In the Chiang Mai part, there are 4 districts and 19 sub-districts. The largest urban area is Chiang Rai Municipality.

In terms of population, the project area represents 38 percent of Chiang Rai Province and 13 percent of Chiang Mai Province (1997 figures, SR-12 pp. 9-12). In consequence, statistics that comprise an entire province may not at all describe conditions in the project area.

The present and future population in the project area has been analysed and reported in SR-12. Recorded developments in recent years (1993-97) indicate a high growth in Chiang Rai Municipality, presumably due to migration, and a low growth elsewhere in the project area.

In 1996, there were 135,028 households in the project area. The average household size was 4.1. The population is evenly distributed between males and females (50.3 and 49.7 percent, respectively, in 1997). 23 percent of the population is below 15 years, and 8.5 percent are more than 60 years old.

A projection of these trends is shown in Table 2.9. The values are uncertain, as it is not known whether the patterns of growth and migration in recent years are valid in the future as well. For example, it is doubtful whether the growth rate of 15 percent per year observed in Chiang Rai can be sustained for several decades. This growth rate reflects a doubling of the population for approximately every 5 years.

	Chiang Rai Municipality	Chiang Rai Province (outside municipality)	Chiang Mai Province	Total
Population 2000	56913	447364	209488	713765
Population 2010	229845	482118	218534	930497
Population 2020	928664	517395	227970	1674028
Base year (1997)	36974	436428	206848	680250
Growth rate	15 pct/year	0.7 pct/year	0.4 pct./year	

Table 2.9: Population in the project area (SR-12, p. 15)

The average household income in the Northern Region was 10,253 baht per month, and the average expenditure was 8,388 baht per month in 1999 (according to National Statistical Office, quoted in Bangkok Post 7 June 2000).

The following socio-economic issues have been reported as characteristic for the project area (SR-12, pp. 50-51):

- Low (or in some years even negative) economic growth in the agricultural sector, due to shortage of water, and high costs of pesticides and fertiliser;
- low investment in the agroindustry sector, due to inadequate or unstable supply of raw materials;
- inadequate banking and insurance services;
- smuggling of commodities (particularly vegetables) from neighbouring countries;
- low education level: 74 percent of the population quits school after the compulsory basic level;
- inadequate health services;
- problems related to drugs, HIV and crime; and
- illegal migration.

Domestic water supply

There are two large waterworks in the Basin, operated by Provincial Water Authority (PWA):

- Chiang Rai Municipality, drawing raw water from Kok River, capacity 36,000 m3/day; and
- Fang, drawing raw water from Mao River, capacity 1,920 m3/day.

Another PWA plant is under construction in Chai Prakarn. Its capacity will be 1,200 m3/day.

Elsewhere, the domestic demand is served by small-scale facilities or individual withdrawals, based on either surface water or groundwater.

The unit demand for domestic supplies is estimated at 312 l/person/day in Chiang Rai Municipality, and 200 l/person/day elsewhere in the basin. With these figures (which may be on the high side), the total demand for domestic supplies (in the entire Basin) becomes 1.7 m3/s.

	Chiang Rai Municipality	Chiang Rai Province (outside municipality)	Chiang Mai Province	Total
Unit demand	312 l/person/day	200 l/person/day	200 l/person/day	
Demand (1998)	13,400 m3/day	88,100 m3/day	41,500 m3/day	143,000 m3/day

Table 2.10: Present domestic water demand

The corresponding return flow is estimated at 80 percent.

2.5 Sector studies

Studies have been made of different economic sectors in the project area. They are reported in various Study Reports (SRs). Below are given short characteristics of the key sectors, as they appear today. Various related development options and constraints are described in Chapter 3.

2.5.1 Agriculture and forestry

Information about agriculture has been acquired from the Chiang Rai and Chiang Mai Provinces Agricultural Offices of Department of Agricultural Extension, and from RID. Findings are reported in SR-8.

In terms of present occupation, agriculture is the most important sector by far. 70 percent of all households in the project area earn their living from agriculture (SR-12, p. 19). Still, agriculture contributes only 13 percent of the joint gross provincial products of Chiang Rai and Chiang Mai (1995 data, SR-12 pp. 5-6).

Typical crops are as follows:

Rice is grown in both the wet and the dry season, glutinous rice for own consumption, and non-glutinous rice for sale. The wet season cultivation period starts in June, with harvest in October-December, depending on the species. The dry season crop is planted in December-January, and is harvested in late April to early May

Maize is mostly grown as an upland crop, and to a small extent as the second crop on paddy fields. In upland areas, one crop can be grown in the early wet season (May to August), and one in the late wet season (August to December)

Soybean is a typical second crop in the paddy fields

Vegetables are other typical second crops in the paddy fields, but are also grown upland. Typical vegetables are garlic, shallot, ginger, chilli, leaf mustard, cabbage and tomato

Fruit trees are mainly grown in the upland, hilly areas. Typical species are mango, longan and lychee

Agricultural land holdings represent 46 percent of the area of Chiang Mai province, and 53 percent of the area of Chiang Rai province (SR-12, p. 30). In comparison, actual cultivation occupies 33 percent of the project area (Table 2.5). Reasons for the less than full utilisation were surveyed in 1996 (Kor-Chor-Chor 2 Kor, cf. SR-12, p. 42). They comprise

- lack of water (45 percent of respondents);
- not profitable (23 percent of respondents);
- poor soil (8 percent of respondents);
- lack of knowledge (7 percent of respondents); and
- other reasons (including labour shortage, floods, etc).

Also, soil erosion is an impediment to cultivation. Soil erosion is caused by a combination of sloping ground and inadequate mitigation practices (SR-8, p. 3).

The farm size varies, but is typically small. The average size is 11 rai (1.7 ha), which is considered as inadequate for families with 5-6 members (SR-8, p. 9). 44 percent of the households have title deeds to their land, and 37 percent have other land holding rights. 18 percent do not own the land they cultivate (SR-12, p. 41). To some extent, upland cultivation may take place on land that is not registered as land holdings.

In 1998, 65 percent of the actually cultivated area was rainfed, while 35 percent was irrigated. The rainfed areas produce one crop per year, while the irrigated areas can produce one or two crops per year. Typical crop intensities on irrigated lands are 110-130 percent only. This is because many farmers seek employment elsewhere in the dry season, due to the risk of drought, and because of uncertain profits, if the costs of consumables exceed the farmgate price of the products (SR-8, p. 1).

Crop cultivation is sometimes combined with livestock, such as ducks and chicken (17 percent of households); pigs (16 percent of households), cattle (3 percent of households); or buffaloes (1 percent of households) (SR-12, p. 45).

Integrated farming is being widely implemented. The King's Initiative Project recommends a 30:30:30:10 percent area allocation for fish pond and water storage; paddy; fruit trees or vegetables; and housing, respectively (SR-8, p. 9, SR-9, p. 11).

Forests cover 47 percent of the project area (Table 2.5). Since 1989, there has been no commercial forestry. Since then, the forest areas have been in a state of restoration, following over-exploitation in the past. The restoration process is supported by a general (national) ban on logging.

2.5.2 Fisheries

In terms of occupation, fisheries plays a minor role only. In the project area, only 0.8 percent of the households indicate fisheries as their main source of income. Most of these are in Chiang Saen (7.2 percent of district population) and in Wiang Chieng (4.9 percent of district population) (SR-12, p. 45). Fisheries contributes 0.2 percent of the gross provincial product (1995 data, SR-12 pp. 5-6).

It is believed, however, that these figures underestimate the significance of the fisheries. From an economic point of view, many people engage in fishing as a side occupation. Experience from elsewhere in the Mekong Basin indicates that fisheries contribute a large part of the protein to the diet.

(Besides, fisheries statistics are notoriously inaccurate anywhere in the world).

In the project area, there is a wide variety of fish species. Between them, previous surveys indicate more than a hundred species. They include several economic species, like for example barp, catfish,

and serpent head fish (SR-9, pp. 8-9). There are also several exotic species, like loach and carp. Some species migrate between the Mekong and the Kok River Basin, where they breed.

The yield is relatively low. The standing stock is estimated at 3-4 kg/rai, which is well below the national average of 15 kg/rai (SR-9, pp. 9-10).

Fishing is mainly practised for own consumption. There is some commercial capture fishery, which is typically done as a side occupation. Fishing gears are simple, like cast nets, pole and line, and, in the wet season, bamboo traps. Some illegal methods have been reported, like electrofishing, poison, and nets with small mesh sizes. A typical commercial catch is 2-6 kg/day in the dry season and 10-15 kg/day in the wet season, which represents and income of some 100-200 baht per day and some 200-300 baht per day, respectively.

In addition to the capture fisheries, there are widespread small-scale hatcheries and fish ponds, for example in connection with integrated farming. The Chiang Rai Freshwater Fisheries Station in Wiang Chai promotes aquaculture, for example based on the favourite species, the Nile tilapia (Oreochromis niloticus).

Photo: Regulatory Fish Encyclopaedia, US Food & Drug Administration, Seafood Products Research Centre

Figure 2.7: The Nile tilapia (length: 25 cm)

2.5.3 Industry

In 1996, industry occupied 13.5 percent of the labour force in the project area (SR-12, p. 22). Most of the industries are located in Chiang Rai, Wiang Pa Pao, and Fang. They are typically agro-industries, producing canned or pickled fruit and vegetables. No figures are available about their contribution to the economy.

2.5.4 Tourism

The provinces of Chiang Mai and Chiang Rai offer a large variety of tourist attractions. They cover both cultural visits, adventures (boating and trekking), natural attractions, shopping, and museums.. Wat Doi Suthep and the Golden Triangle are famous worldwide. There are numerous temples, landscapes and natural attractions, as well as activities like cultural shows and festivals.

In consequence, there is a large and steadily growing number of visitors to the provinces. As shown in Table 2.11, tourism paid a visible contribution to the economy, both in terms of national and foreign currency.

Province	Arrivals (persons)	Foreign arrivals (pct. of total)	Average spending (baht/person/day)	Average stay (days)	Total spending (bio. baht)
Chiang Rai	942725	28	2254	2.6	5.4
Chiang Mai	2770987	38	2444	3.1	20.9
TOTAL	3713712	35	2396	2.9	26.3
Note: These statistics cover the entire provinces, and not only the parts that are located inside the project area					

Table 2.11: Tourist arrivals and spenditure (1997 data, SR-12 p. 16)

2.5.5 Hydropower

Today, there are three mini-hydropower plants in the project area. All are located in the Fang sub-basin. They are listed in Table 2.12.

Location	Capacity (kW)	Yield (GWhours/year)	Type	Authority
Mae Kum Luang	2 x 3,200	15.6	Run-of-river	DEDP
Mae Mao	2 x 2,300	9.1	Reservoir	DEDP
Mae Chai	875	4.8	Run-of-river	PEA
Total	8,675	29.6		

Table 2.12: Existing hydropower plants (SR-1, p. 17)

Figure 2.8: Mae Mao dam

2.6 Administrative framework

Legislation

Thailand has an Irrigation Act, a Groundwater Act, and an Act for River Management. The Groundwater Act of 1997 regulates the extraction of subsurface water by drilling techniques. The Enhancement and Conservation of National Environmental Quality Act was promulgated in 1992. It builds on a previous environmental law from 1975.

Principles of The Enhancement and Conservation of National Environmental Quality Act (1992)

1 To promote participation by the people and by NGOs

2 to structure the environmental management

3 to define and delineate the authority of government agencies, state enterprises, and local administrations

4 to control pollution by provision of disposal and treatment systems

5 to clarify duties and responsibilities of persons involved in causing the pollution: and

6 to prescribe incentives for environmental protection, such as funding and grants

(After Matthews and Mallikamarl 1995, p. 2)

A Water Law has for a long time been in preparation by the National Water Resources Committee (under the Prime Minister's Office). Progress is slow because the subject is sensitive.

A document from the Faculty of Law, *'Institutional Arrangements for the Administration and Management of Natural Resources and Environment of Watersheds in Thailand',* concludes that the existing laws and regulations, if effectively implemented, are adequate for protection and management of watershed management. The concept of water rights, the author concludes, may have to be introduced as to manage water resources effectively.

Administrative levels

The main administrative levels are as follows (SR-13, p. 8):

1 The Government

2 Provinces *(changwat)*

3 Districts *(amphoe);* they can be metropolitan *(nakhon)* (of which there are none in the project area, or towns *(muang)* (like Muang Chiang Rai)

4 Sub-districts *(king amphoe)*

5 Communes *(tambon),* headed by a tambon council and an administrative organisation

6 Villages *(muu baan),* headed by a village head *(por luang)*

There is a development towards decentralisation of political power and financial authority. The commune (tambon) administrations are new and are not yet consolidated.

The administrative structure of the project area is shown in Table 2.13.

Province *(changwat)*/ district *(amphoe)*	Town *(muang)*	Sub-district *(king amphoe)*	Commune *(tambon)*
Chiang Rai			
Muang	1		14
Phan		1	15
Mae Suai		2	6
Wiang Pa Pao		2	7
Wiang Chieng Rung		1	2
Wiang Chai		1	4
Mae Lao		2	5
Mae Chan		4	9
Chiang Saen		1	6
Chiang Mai			
Chai Prakarn		1	4
Fang		2	6
Mae Ai		1	5
TOTAL	1	18	83
Note: Kok River Basin also includes small parts of Doi Luang and Mae Fa Luang districts in Chiang Rai province; and Phrao district in Chiang Mai province			

Table 2.13: Administrative units in Kok River Basin (SR-13, p. 9)

Agencies and institutions

A variety of ministries, agencies and institutions are in some way involved in the national management of water resources and natural resources. Examples are, in random order:

- NESDB (under the Prime Minister's Office) undertakes (among many other activities) review of national sector budgets and sector plans, as prepared by the different ministries, and controls their concordance with the national development goals
- National Environment Board (NEB) is chaired by the Prime Minister. There are eight Ministers on the Board, representing Science, Technology, and Environment, Defence, Finance, Agriculture and Cooperatives, Transport and Communications, Interior, Education, Public Health, Industry, along with the secretariat of the National Economic and Social Development Board, the Secretary-General of the Board of Investment, and the Director of the Bureau of the budget. Additionally, up to eight persons from environmental fields with at least half from the private sector. NEB makes policy recommendations to the Cabinet, to decide whether to approve action plan recommendations of the Pollution Control Committee, to consider for approval emission and effluent standards proposed by the Minister of Science, Technology, and Environment, and to supervise other agencies to ensure systematic operation of the laws relating to the enhancement and conservation of environmental quality. NEB undertakes environmental screening of large or risky projects, and environmental harmonisation between sector plans in connection with the over-all national economic and social development planning
- Ministry of Science, Technology and Environment (MOSTE) is in charge of several agencies, including Office of Environmental Policy and Planning (OEPP); Department of Energy Development and Promotion (DEDP); Department of Pollution Control (DPC); and Department of Environmental Quality Promotion (DEQP); Also, Thailand Institute of Scientific and Technological Research (TISTR) is under this ministry

- OEPP has the main responsibility for formulating environmental policy and planning, as well as overseeing and carrying out environmental impact assessments of governmental and private sector projects. The Environmental Fund management is also coordinated by this agency. OEPP has four regional offices (Eastern, Northeastern, Southern, and Western). Each regional office is to coordinate the management of natural resources and pollution control within its region. This includes preparing preliminary assessments and making recommendations on whether to designate areas for environmental and conservation protection and/or pollution control. Technical cooperation on the management of natural resources and the environment is to be provided to both governmental agencies and the private sector

OEPP undertakes (among many other activities) watershed classification. This is done by the Natural Resources and Environmental Management Division of OEPP. Thailand was the first country in Southeast Asia to develop a classification system for watershed areas. The procedure, as endorsed by the Cabinet, considers 5 classes based on physical characteristics (slope, relief, land form, soil, and vegetation). Class 1 is subdivided into 1A and 1B. Class 1A comprises protected forest and headwater areas at high elevations and steep slopes. Subject to endorsement by the Cabinet, all residents living in Class 1A areas are supposed to be resettled in other areas. Class 1B has similar features but includes agricultural land use and may be said to be an adaptation to reality as more than 60% of northern watershed areas have been encroached.

- DEDP was formed according to the 1992 Energy Development and Promotion Act. DEDP is responsible for investigation, development, supervision and execution of energy production, processing, distribution, utilisation and conservation. This includes hydropower development and production, pump irrigation, and related surface water regulation and hydrological monitoring. DEDP owns and operates the Chiang Rai weir
- DPC formulates and evaluates measures to control, prevent and remedy environmental problems caused by pollution. The Department formulates national environmental quality standards and undertakes environmental monitoring, covering water and air quality, noise pollution, and hazardous substances and solid waste
- DEQP serves as a facilitator for cooperation, coordination and information exchange among government agencies, state enterprises and the private sector in matters concerning environmental quality. DEQP certifies environmental laboratories and transfers technology to government and non-government agencies. Moreover, DEQP promotes public awareness, proper understanding and knowledge about environmental protection and conservation of environmental and natural resources
- Department of Mineral Resources, Ministry of Industry, undertakes (among many other activities) nation-wide hydrogeological mapping, and implementation of groundwater development projects in specific areas
- Natural and Water Resources Board and the Office of Water Resources under the Prime Minister's Office
- The Water Resources Policy Committee under the Prime Minister's Office is in charge of preparing a national water law, and for drafting national water resources development strategies
- Royal Forest Department, Watershed Management Division, is responsible for the preparation of a National Watershed Action Plan. The plan will be implemented by 189 watershed management units, and will involve local participation and NGOs. The modes of technical implementation are: (1) Physical structures, (2) vegetative barriers, (3) reforestation and afforestation, and (4) community-based resource management
- RID, Ministry of Agriculture and Cooperatives, was formed to serve the agricultural sector, but today, the field of activities has expanded, for example to rural water supply. There is a

provision for RID to charge a user fee to cover operation and maintenance of irrigation systems, but the issue is controversial, and the provision is not applied (SR-12, p. 48). The Kok-Ing-Nan diversion project (described in Section 3.4 below) is being planned by RID. In general, however, the present development typically comprises small-scale irrigation schemes, which are implemented both by RID and several other agencies. RID's Office of Hydrology and Water Management is in charge of a substantial part of the national hydrological monitoring and data collection

- EGAT under the Prime Minister's Office was formerly the implementing agency for large hydropower schemes. No such schemes are presently in preparation
- Ministry of Public Health is involved in water supply to villages
- Provincial Waterworks Authority is in charge of public water supply to Chiang Rai
- The Rural Development Programme implements small-scale water supply schemes
- Department of Fisheries, Ministry of Agriculture and Cooperatives, is (among many other activities) engaged with freshwater capture fisheries and aquaculture, including conservation of species, extension services, technology transfer, statistics, and related research. DoF collaborates with Land Development Department, RID, and EGAT, for example on reservoir fisheries development. There is little scope for development of paddy field fish cultivation, due to pollution from pesticides, and shortage of water. Integrated cultivation (for example farming + fish ponds + duck + fruit) seems to represent a particular development potential. The *'community pond project'* is a major activity, which has proceeded for 20 years

The P*eople's Irrigation Projects* is a particular institution of northern Thailand. They are informal, but well functioning cooperatives that implement and operate irrigation systems according to long-standing traditions (SR-13, p. 7).

NGOs

In 1999, there were 21 NGOs based in Chieng Rai or having an office in Chiang Rai (SR-13, p. 6). The largest ones are YMCA; Association for Population and Community Development; and CARE International Thailand. Their activities include community development, support to hilltribes, assistance to various underprivileged groups, environmental preservation. Several NGOs are quite influential. Sometimes, they function as opinion leaders.

National planning practices

There are 2 planning cycles, a 1-year plan and a 5-years plan (currently no. 8), with annual as well as additional, occasional revisions. Typically, major development schemes will be addressed in the 5-years plan, while smaller activities fall under the 1-year plans. Strict compliance with the plans is difficult, because the demand changes, and so do the budget allocations. Small projects, or urgent major projects, can be implemented outside the plans, under a 'special budget allocation' by the Budget Bureau.

The planning levels are shown in Figure 2.9.

Small-scale projects go 'bottom-up', from the provinces, or directly from the affected people, while medium and large projects are defined and promoted at the central level.

In addition, there can be specific master plans and development plans etc. for specific areas or topics. River basin development plans have been prepared for Mun and Chi, Chao Phraya, and others.

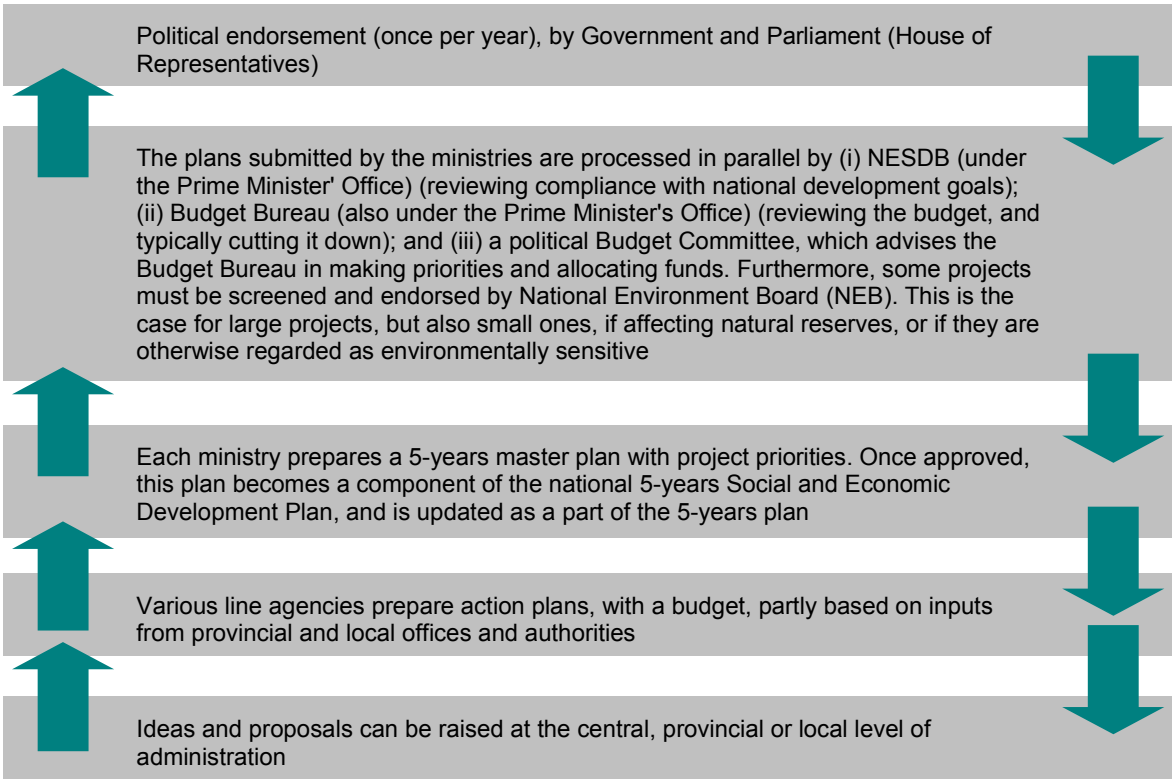


Figure 2.9: Outline of the national planning procedure

OEPP has published a Policy and Prospective Plan with visions and goals of the national environmental quality during 1997-2016. A sub-committee with 27 members including ministries and scientists were appointed by the Government to envision the long-term enhancement of environmental quality. The document presents a policy and a prospective plan, as well as sector policies and guidelines for environmental management. Line agencies will implement policies and guidelines according to the Enhancement and Conservation of National Environmental Quality Act of 1992, and by formulating national and provincial Environmental Quality Management Plans.

2.7 Related development programmes

Mekong River Commission

The Mekong River Commission (MRC) is a permanent regional body formed by Cambodia, Laos, Thailand and Vietnam. Its mandate is laid down in the Mekong Agreement from 1995. Its work is supported by National Mekong Committees in each member country.

The Mekong Agreement includes articles on intra-basin and inter-basin use of the Mekong River in the dry and the wet season, and charges the MRC Joint Committee with preparing and proposing rules for water utilisation and inter-basin diversions.

MRC is supporting development towards *'an economically prosperous, socially just and environmentally sound Mekong river basin'*. According to its Strategic Plan for 1999-2003, the mission of MRC is *'to promote and coordinate sustainable management and development of water and related resources for the countries' mutual benefit and the people's well-being, by providing scientific information and policy advice, and implementing strategic programmes and activities in accordance with the 1995 Mekong Agreement'*.

MRC is implementing several regional development programmes related to water resources and the environment. Examples are listed below:

- *The Water Utilisation Programme (WUP)* has been in progress since 1999, with an expected duration of 6 years. It will provide mechanisms for coordinated water management in the Basin and among the riparians, reasonable and equitable water utilisation by the countries of the Basin, and for protecting the environment, the aquatic life and the ecological balance of the Basin. This will be pursued by preparation of rules for water quantity and quality and for information exchange, notification, consultation and agreement, in accordance with the Mekong Agreement, development of procedures for implementation of the rules, and related capacity-building.
- *The Basin Development Plan (BDP)* has been in preparation since 1999, with a 3-4 years time horizon. The BDP will supply the general planning tool and process that the MRC Joint Committee can use as a blueprint to identify, categorise and prioritise the projects and programmes to seek assistance for and to implement the plan at the basin level. The planning is regarded as a continuous process to contribute to improvement of standards of living and support environmental sustainability in the Mekong Basin. The BDP is intended as a framework for cooperation among the riparian countries to utilise the full potential of sustainable benefits of the water and related resources of the Mekong Basin. Initiatives, based on the most effective management of water, and related natural and human resources, will be identified, developed and implemented. Interdependent subregional development will be encouraged through cooperative actions initiated by the MRC and other agencies concerned.
- *The Environment Programme* aims at integrating environmental aspects at all steps of the project cycle in the development of the Mekong River's water and related resources. Environmental planning and management involves educational, structural, institutional, legislative, and socio-economic aspects, both at the national and the basinwide level. Like other MRC programme, the Environment Programme is targeted towards regional, rather than purely national issues
- *The Fisheries Programme* comprises the following components: (i) Inland capture fisheries; (ii) aquaculture development; (iii) strengthening of fisheries institutions; and (iv) coordination and information dissemination. The programme is revised every 5 years, the present phase covering 1999-2003.
- *The Agricultural and Irrigation Programme* has the following objectives: (i) To ensure enhanced international cooperation among the Basin countries to promote sustainable agricultural development; and (ii) to optimise water use for agricultural production and other agricultural sectors in the Basin that will raise the living standard of the rural population and ensure the conservation of the environment. Specific objectives relate to technical, social, institutional, environmental, and economic and financial issues. The strategy is to implement an integrated programme, which contains a package of appropriate interventions that will ensure the sustainability of agricultural development. The framework of interventions includes optimising water use for agricultural production, improved agricultural productivity, social development and farmers' participation, institutional development and capacity building, environmental sustainability, and economic and financial sustainability.
- *The Hydropower Programme,* which (among several other activities) has mapped the hydropower potential and development opportunities for the Lower Mekong Basin, and formulated a *'Hydropower Development Strategy for the Mekong River Commission'* that was endorsed by the Joint Committee in September 1998.
- *Integrated GIS and Statistical Databases for Natural Resources Management*
- *The Wetlands Conservation Programme*

Furthermore, MRC has promulgated a gender policy and a public participation policy.

ASP

The Thai Agriculture Sector Programme (ASP) aims at sustainable growth in the agricultural sector. This objective will be pursued by

- increasing the agricultural productivity;
- strengthening the export of agricultural products by improving their international competitiveness; and
- restructuring of agricultural institutions, and improved governance.

The Programme comprises 20 projects in 6 areas:

1 Increased productivity in irrigated and non-irrigated areas;

2 development of commodity quality, and improved managerial capability;

3 community development;

4 research;

5 establishment of New Economy Zones; and

6 structural changes of organisation, institutions, and information systems of the agricultural sector.

The total budget is 22 billion baht, part of which may possibly be borrowed from ADB.

The programme involves cost recovery for public irrigation schemes: A service fee will be charged from the users to cover the expenses.

For this and other reasons, the ASP is controversial. It has not yet been initiated.

GMS

The ADB initiative *'Economic Co-operation in the Greater Mekong Subregion (GMS)'* is a major regional collaboration programme. It was initiated in 1992. It comprises Cambodia, the Yunnan Province of China, Laos, Myanmar, Thailand and Vietnam.

The GMS programme covers six sectors: Transport, hydropower, tourism, economic corridors, environment, and drug control. Developments in these sectors are discussed at annual ministerial meetings. At a slightly lower level, some of the sectors are discussed at so-called Fora, such as the Transport Forum. The Fora are further divided into working groups. Other sectors, such as tourism, are only discussed in a working group without a Forum.

A *'Strategic Environmental Framework'* is presently being prepared under the GMS programme. The over-all objective is to promote the integration of environmental considerations with economic planning and implementation, in order to improve environmental protection. For this purpose, the project will examine applied systems for economic and environmental development planning and management, and will recommend on strengthening as required. Particular attention will be given to public participation, involvement of indigenous people, institutional co-ordination, environmental management, and capacity-building. The project started in December 1998 and will proceed for 22 months. It considers 3 scenarios for regional development: 'High', 'medium', and 'low'. It is executed by ADB in collaboration with MRCS and UNEP.

3

Development potential and development effects

This chapter describes the options and constraints that, between them, delineate the development opportunities as they appear in today's perspective. They comprise external forces, the demand and availability of raw water, various issues related to specific sectors, and environmental and social consequences of development. Some of the aspects can be controlled by management, while others cannot. Many of the opportunities and constraints will change with time. In other cases, our knowledge about them and the understanding of their significance will change with time, even if the potential as such remains unchanged. (This is for example the case with availability of raw water resources).

3.1 External forces

The development of Kok River Basin is exposed to several external driving forces. These are external determinants, or causes in cause-effect relationships that affect the Basin and its water resources, and hereby, directly or indirectly, the course of its development.

Driving forces can be *'structural linkages'* (institutional or between parallel planning processes), *'political',* or they can be *'natural'* (for example related to rainfall, morphological processes, El Niño events, or natural disasters). A separate category of driving forces is emergence of new technologies, which from time to time can generate important stepwise (and often unpredictable) shifts of the planning basis, for example by opening new *'opportunity windows'* for development. Some driving forces can be managed to some extent, but it is a characteristic to a driving force that it cannot be entirely controlled by the participants in the planning process.

Some of the forces are well known, but are listed below as an argument that a future without visible changes is unlikely.

1 Pressure from present national imbalances, cf. Table 3.1

2 Population pressure. Today, the majority of people in the project area is occupied with agriculture. The primary agricultural production cannot sustain more people than today. Rather, in the future, it is likely that a (much) higher agricultural output can be produced by (much) fewer people. The result can be a migration from the countryside to towns inside and outside the project area, and a need to generate many new jobs in other sectors than agriculture. From a national point of view, as many jobs as possible should be generated locally, in order to prevent an excessive migration to metropolitan centres

3 Pressure from global and regional competition. The temporary competitive advantage of low salaries that assisted Thailand in the early stages of industrialisation is already irreversibly lost. Industry and manufacture that is mainly based on low salaries will develop in other countries in

the region (and globally) where salaries are much lower than in Thailand. It is necessary to pursue other competitive advantages

4 Increased demand of public services. It is quite possible that twenty years from now, the population will demand much more comprehensive public services, for example within education for the children, health services, and in other areas. Such services must be funded, which must in turn be based on a higher general income

5 Energy prices. The national and global energy prices are related, and are being even more closely linked by the regional power distribution network presently being developed. If the energy prices escalate (over a time scale of some decades), the economic feasibility of many hydropower schemes will escalate correspondingly

Other external forces may influence the course of development: The possible global climate change, the information technology revolution, and others that are not yet identified or understood.

- Imbalance between employment and production with still about 60 percent of the work force having primary occupation in agriculture, while agricultural value added amounts to only 15 percent of the gross domestic product
- Regional imbalance. Most of the dynamic and successful industrial and service sectors are located in and around Bangkok. In 1989, real per capita income in the Bangkok Metropolitan Region was almost three times the national average, while that for the Northeast was only 40 percent of the national average. The income differentials between the Bangkok region and most other regions have been widening over the last decade
- Educational imbalance. The vast majority of the population have only primary education or less, while a small minority (particularly those in the larger cities) are very well educated, with access to the prosperous and high paying jobs
- Income imbalance. Resulting from the above imbalances, there are large income differentials between agriculture and non-agriculture, rural and urban areas, between various regions, and different educational groups. The income share of the richest 20 percent of the population has increased from 49 percent of total income in 1975/76 to 55 percent in 1988/89, while the income share of the poorest 20 percent fell from 6 percent to 4.5 percent during the same period
- Environmental imbalance. Past economic development has led to severe natural resources and environmental problems, both rural and urban. Thailand is still some way off achieving a semblance of harmony between economic and natural resources and environmental development

Table 3.1: Socio-economic imbalances (TDRI, Annual Report 1992)

The impact of such forces on the future utilisation of water resources and natural resources in general cannot be predicted. Between them, however, they seem to point at three needs:

(i) A need of change: Within a planning horizon of 20 years, it is likely that water resources will in any case be utilised in a way that differs visibly from today;

(ii) a need of higher value added: As the water resources are finite, and not far from full exploitation, increased welfare will be subject to a much higher earning generated per cubic metre of water utilised; and

(iii) a need of sustainability: In order to neutralise the imbalances and avoid simultaneous or subsequent negative side effects, the development must take place in harmony with basic, agreed socioeconomic and ecological long-term goals

3.2 Domestic demand

A projection of the domestic demand is shown in Table 3.2. The projection reflects the trends observed in the mid 1990-ies. It is based on the population growth shown in Table 2.8, and unchanged unit demands as shown in Table 2.9. Under these assumptions, the growth will be quite moderate, except in Chiang Rai Municipality, where the demand will increase from 0.2 m3/s today to 3.4 m3/s in 2020.

It is expected that piped supply will be extended to more people in the future. Possibly, groundwater (if available) will become more common as a raw water resource for domestic supply. Key issues in connection with the long-term development comprise

- the continued availability of adequate amounts of surface water. (This means that the minimum flow can cover both the domestic demand and the ecological demand at the points of extraction);
- an acceptable surface water quality;
- the groundwater potential and the groundwater quality; and
- the distribution losses in the towns and other areas with piped supply.

	Chiang Rai Municipality	Chiang Rai Province (outside municipality)	Chiang Mai Province	Total
Unit demand	312 l/person/day	200 l/person/day	200 l/person/day	
Demand (2000)	17,800 m3/day	89,500 m3/day	41,900 m3/day	149,200 m3/day
Demand (2010)	71,700 m3/day	96,400 m3/day	43,700 m3/day	211,800 m3/day
Demand (2020)	289,700 m3/day	103,500 m3/day	45,600 m3/day	438,800 m3/day

Table 3.2: Future domestic water demand (cf. Tables 2.8 and 2.9)

3.3 Sector development

Agriculture and forestry

Today (as noted in Section 2.5.1), agriculture in Kok River Basin is subject to several constraints. The most important are:

- Scarcity of water;
- land that is (in some areas) less suited or even unsuited for cultivation;
- a low and unsafe profit margin for rice (the most important crop), where the production costs are close to the production value; and
- a land ownership structure characterised by many farmers having limited or no ownership of the land they cultivate.

The following development options have been identified (SR-8, p. 9-10):

- A gradual shift from paddy cultivation to cultivation of high value crops, possibly combined with a gradual crop diversification, in accordance with agro-industrial demands;
- promotion of integrated farming; and

- development of fish ponds, including better supply of fingerlings.

Considering present constraints, *the long-term development must aim at higher output value per unit of water and per unit of labour.* This goal is in accordance with national policies for agricultural development. It can best be achieved by the first-mentioned strategy. In addition, the value of the crops can be highly increased downstream of the farmgate, by different ways of processing, and by improved distribution and marketing. For the sake of sustainability, the development must take place in ways that reduce the environmental effects (like soil erosion and discharge of pollutants).

Experience indicates that 'top-down' implementation of governmental development policies have little or no impact, due to reluctance from the target groups (SR-8, p. 9). The traditional paddy cultivation is not very profitable, but still it is regarded as safer than the alternatives. This reflects a preference of low risks rather than a higher, but uncertain profit, which is rational for farmers that cannot afford an extended period with no income and no food for their subsistence.

Separate goals must be pursued for upland agro-forestry cultivation. The forests ecosystems are fragile and under pressure. Agro-forestry is an option for sustaining the upland and mountainous ecosystems, while, at the same time, stabilising the living conditions of the farmers (SR-6, p. 23). Management options comprise (i) stabilisation of sloping areas; (ii) maintenance and improvement of the soil fertility; and (iii) improvement of the microclimate (SR-6, p. 25). In the medium term, in order to prevent stagnation and marginalisation, additional sources of income must be sought as a supplement to subsistence cultivation.

In the long term, there is a clear scope for commercial forestry. Today, the forest are still in an early stage of restoration after unsustainable over-exploitation in the past. Once restored, and with proper management, a part of the forest area will become an important commercial asset.

Fisheries

Today, the fish stock in the Basin is in a state of gradual deterioration, possibly due to over-exploitation and pollution. Yields are small, and the commercial value is insignificant.

Development of capture fisheries must aim at *(1) preservation of biodiversity and habitats (including water quality, important migration routes and breeding grounds), and (2) prevention of over-exploitation.* The potential for commercial development is small, but the possibility exists of increasing the yield from capture fisheries in (present and future) reservoirs.

A particular concern is the risk of contamination of edible fishes by pesticides from agriculture.

The biodiversity of the rivers and wetlands can serve as an important indicator for the general environmental state of the Basin.

Favourable areas for development of fish production are found in Fang sub-basin (Chai Prakarn, Fang and Mae Ai districts), Upper Lao sub-basin (Wiang Chai district), Upper Kok sub-basin (Muang Chiang Rai and Mae Ai districts), and Lower Kok (Chiang Rai, Mae Suai, Mae Lao and Wiang Chai Districts). Capture fisheries can be enhanced by preserving the natural vegetation in the rivers and on the floodplains, while aquaculture can be developed on the floodplains. The potential is estimated at around 500 t of market size fish at a value of around 10 million baht per year.

Development of aquaculture can take place on a small scale, either as separate (intensive or semi-intensive) monocultures, or in connection with integrated farming. In either case, the development can be regarded as an alternative or a supplement to agricultural development, and with the same objective: *Improvement of the value generated per unit of water*

Industry

Today, the main economic development takes place within the industrial sector. There is a large potential for added value in general, and in particular for value generated per unit of water and per unit of labour. On the medium term, industry must absorb a main part of the increasing labour force. In the long term, however, employment will gradually shift towards the service sector.

The industrial development must take place in accordance with national policies. In Kok River Basin, the following key priorities have been identified:

- *Preservation of water resources:*
  - A low net withdrawal of surface water; and
  - an effective prevention of release of toxic compounds;
- *development of agro-industries that can enhance the value of local agricultural products; and*
- *support to de-centralised development, which can reduce the urban migration.*

Toxic compounds are heavy metals and certain organic compounds, like chlorinated or aromatic hydrocarbons. Prevention of their release does not only relate to sewage, but to air pollution and solid waste as well. This is because air pollution can contaminate the water resources, and solid waste can cause air pollution and/or contaminate the groundwater. Toxic compounds released in sewage can end up in the sludge from the treatment plant, from where they will spread into the environment. From any point of view, socio-economic as well as ecological, the only viable control point for toxic waste is at its source. Technically, this is fully possible. In most cases, the costs are moderate, or even negligible in case of new industrial plants and processes that have been designed with a view to this requirement.

Tourism

Tourism is an important sector today, and with a strong potential for a continued growth. The sector appears as an attractive option for economic development in the medium term, and, in case of prudent management, in the long term as well.

In the project area, tourism is closely related to the environment: It partly depends on it, and is partly a threat to it. Low-cost tourism and mass tourism is on the balance in this respect, while high-end luxury tourism and ecotourism may be a win-win strategy.

The development should aim at *higher earnings per day spent by tourists, minimising the environmental and social impact, and maximising the socio-economic benefits.* A higher average duration of visits may be pursued in the towns or near the towns, where the present variety of attractions may be further expanded: Cultural shows, adventure parks, golf courses, country clubs, etc. Outside the urban areas, unit earnings should be given higher priority than volume. This is for the sake of sustainability. Ecotourism (trekking and rafting) should be developed in terms of quality, rather than in terms of quantity, lest the charm will fade and the tourists disappear, leaving a degraded environment behind.

Hydropower

Two hydropower schemes are planned:

- Nam Kok hydropower project (in Myanmar) (storage volume 3,033 Mm3); and
- Upper Fang multi-purpose project, for hydropower and irrigation (storage volume 50 Mm3).

The Nam Kok project is big. If implemented, it will cause a general, positive change in the water availability in the Upper and Lower Kok sub-basins.

Additional information about the schemes is given in Section 3.4.

There is scope for an additional (although moderate) development of hydropower in connection with some of the planned irrigation reservoirs (see Section 3.4). The potential is not pursued due to public opposition (SR-1, p. 17).

In general, the feasibility of hydropower schemes is highly sensitive to the price of energy. The most likely scenario is that energy prices will escalate over the next decades. If so, there will be a strong incitement to implement schemes that are feasible or nearly feasible with today's cost-benefit ratio.

Service

To judge from global trends, the majority of the population may eventually be occupied within the service sector. This sector is characterised by a high added value per unit of labour, and it does not draw on water resources nor other natural resources to any significant extent.

Summary

A rough indication of the demands and implications of each sector is given in Table 3.3. In this table, a distinction is made between demand of water and net consumption of water. For example, fisheries require an ample availability of surface waters, but does not consume any. The impact of this sector can possibly be high, in case of over-exploitation (for capture fisheries), or pollution (for aquaculture).

Sector	Water demand	Net consumption	Extent of possible environmental impact
Agriculture	High	High	High
Forestry	n/a	'Negative' 1)	'Positive' 2)
Fisheries	High	Nil	High
Industry	Low/intermediate	Low/intermediate	High/intermediate
Tourism	Intermediate/high	Nil	Intermediate
Hydropower	High	Nil	High
Service	Low	Low	Nil
1) Meaning that forestry can add to the generation of water resources 2) Meaning that forestry can improve the state of the environment			

Table 3.3: Summary of water demand, consumption and impact

3.4 Water availability

Regulation

In addition to the existing Mae Mao reservoir (Table 2.11), there are nine planned reservoirs in Kok River Basin, including the Nam Kok project in Myanmar. Between them, they will control some 40 percent of the entire catchment. Their locations are shown in Figure 3.1, and key figures are listed in Table 3.4.

A network diagram of existing and planned regulation is shown in Figure 3.2.

The Nam Kok Hydropower Project in Myanmar is by far the largest. It will flood an area of 120 km2 to obtain a storage volume of 3,033 Mm3. Located at the downstream end of the Myanmar sub-basin, it will control 88 percent of its catchment area. If implemented, this scheme can reduce the downstream wet season flow by 10 percent, and increase the downstream dry season flow by 30 percent.

In the project area itself, there are eight planned reservoirs. They are located in Fang, Upper Lao and Suai sub-basins. The Upper Fang Multipurpose Project is intended for hydropower and irrigation, while the remaining ones are for irrigation only. The projects will control some 20 percent of the Fang sub-basin, some 26 percent of Upper Lao sub-basin, and nearly all of the Suai sub-basin.

In total, the planned projects will generate an irrigation project area of 205,000 rai. This is a 30 percent expansion of the present irrigation project area (which is 675,460 rai, cf. Table 2.2).

Figure 3.1: Location of planned reservoirs (SR-1, p. 20)

Sub-basin	Project	Catchment area	Storage	Potential irrigation area
Myanmar	Nam Kok Hydropower	2,953 km2	3,033 Mm3	-
Fang	Upper Fang Multipurpose	140 km2	50 Mm3	18,125 rai
Upper Lao	Thalop Luang	85 km2	15 Mm3	9,000 rai
	Huai Krai	70 km2	49 Mm3	28,000 rai
	Nawang	85 km2	35 Mm3	13,000 rai
Suai	Mae Chedee	165 km2	35 Mm3	36,000 rai
	Mae Pun Luang	233 km2	53 Mm3	55,000 rai
	Mae Yang Min	146 km2	32 Mm3	39,000 rai
	Mae Suai	437 km2	74 Mm3	7,000 rai
1 rai = 0.16 ha = 0.0016 km2				

Table 3.4: Capacity of proposed reservoirs (SR-1, p. 21)

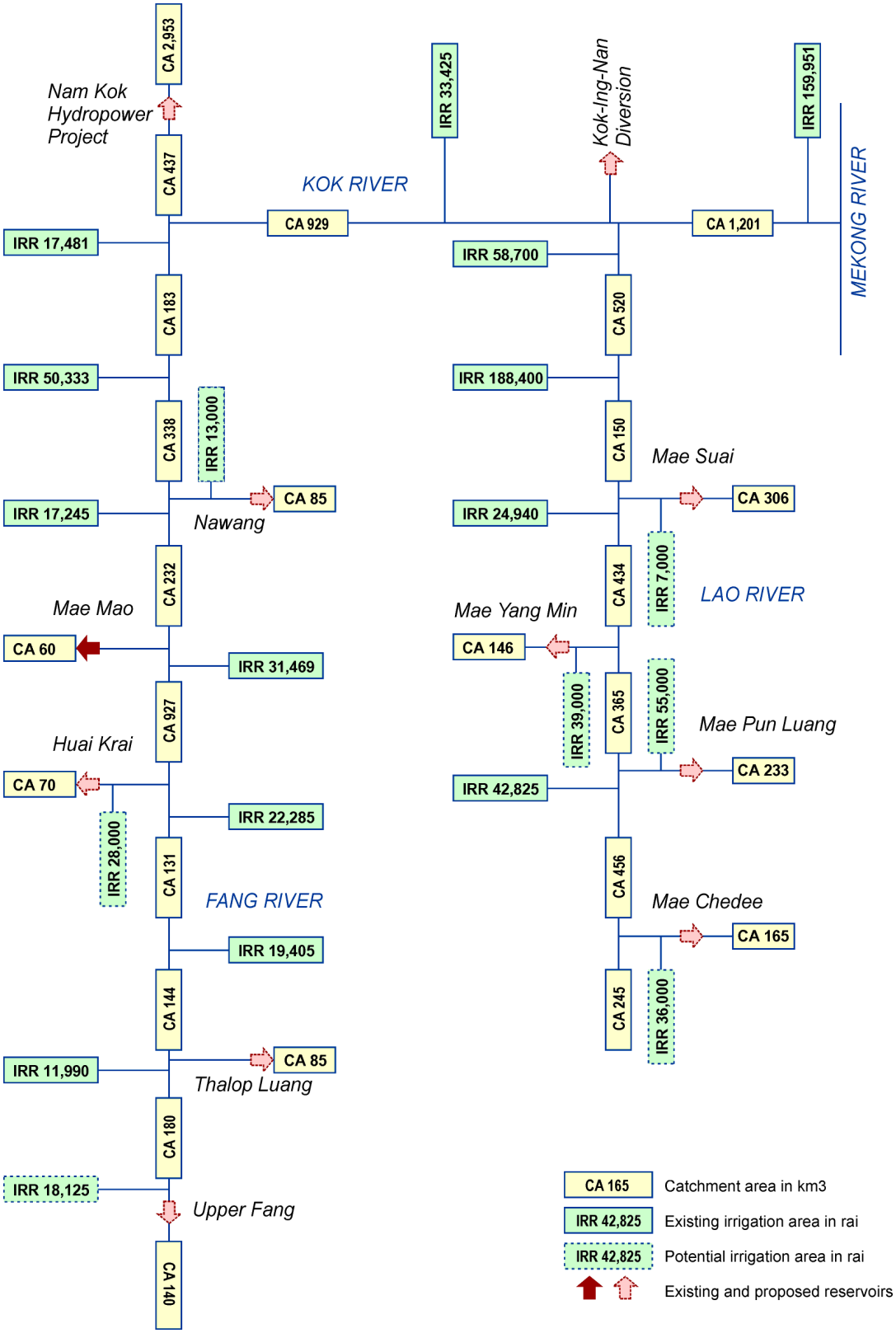


Figure 3.2: Network diagram of present and future regulation (SR-1, p. 44)

The effective impact is larger, because the scarcity of water implies that not all the potential irrigable area can actually be irrigated, particularly in the dry season. Model simulations reported in SR-1 (pp. 50-57) show that the actually irrigated areas will increase by 55 percent and 33 percent in the dry and the wet season, respectively (or 130,000 rai and 638,000 rai).

The regulation will also reduce the flood risk in the wet season. The average flow (for the entire basin) is expected to decrease by 30 percent (SR-1, p. 57).

From a hydrological point of view, the planned development is feasible and useful, although the model simulations made under the present project indicate that the reservoirs (as conceived today) may be over-designed in terms of capacity.

The social and environmental costs may turn out to be significant and possibly, in some cases, prohibitive.

The Nawang Reservoir has the important side objective to serve the domestic demand in Fang District (SR-1, p. 61).

There is a need of rehabilitation or upgrading of some of the existing schemes: Mae Lao, and Chai Sombat. There is scope for upgrading of the People's Irrigation Projects, under the responsibility of DLA (SR-1, pp. 14 - 16).

The Kok-Ing-Nan Project

The planned Kok-Ing-Nan project is a large scheme for diverting water from the Kok Basin via Ing River to Nan River and the Sirikit Dam in Chao Phraya River Basin. The rationale behind the scheme is to utilise an excess capacity in the Sirikit Reservoir by drawing water from the Kok Basin in the wet season.

The main project components are (i) The Kok diversion dam (which is already constructed, just upstream of the Kok-Lao confluence); (ii) the Ing diversion dam; (iii) the Yao flood control dam; (iv) a river training (and capacity augmentation) scheme for Yao River; (v) a 52 km tunnel from Chiang Rai to Nan; and (vi) some 65 km of canals. The estimated costs are some 40 bio. baht. The scheme has been in preparation for more than two decades.

According to present plans for operation, a total of 1,800 Mm3/year will be diverted, which is about 51 percent of the annual flow at the diversion point. The diversion will take place in June through December. In January through May, no water will be diverted (SR-1, p. 51). (According to the 1995 Mekong Agreement, inter-basin diversions from Mekong tributaries are subject to notification to the Joint Committee of the Mekong River Commission).

Feasibility studies and environmental impact studies are in progress (by early 1999). According to information received from RID, the environmental impact is expected to be within fully acceptable limits.

Non-structural development measures

Non-structural development measures are generally attractive (if they exist as an option from case to case). Their environmental impact can be negligible, or even positive, and the demand of capital and the rate of return can be highly favourable.

Non-structural measures comprise:

- Management and operation of irrigation systems, including reduction of losses;
- choice of crops (for example, a shift from rice to any other crop will save a lot of water);
- soil conservation (to retain water in the root zone); and
- cultivation cycle and routines (for example integrated farming).

Model studies made under the present project indicate that the water efficiency can be improved from around 30 percent today to around 40 percent in the future by a combination of rehabilitation of existing irrigation systems and non-structural measures. This would allow for an extension of the irrigable area by 10 and 7 percent in the wet and the dry season, respectively. This improvement can be achieved at little or no environmental cost.

Groundwater

Today, groundwater plays a small role as a water resource in the project area. Only small-scale withdrawals take place, to serve villages, single homes, and minor industries outside of the urban areas.

The information available about groundwater availability and quality is inadequate. It is not known whether there is a potential for exploitation, nor whether the quality is suited for various purposes, such as public supply.

Groundwater cannot replace surface water as the main raw water source, and withdrawal of groundwater will not add to the total (surface plus ground-)water resource of the Basin. The increased infiltration for recharge will reduce the surface runoff accordingly. The total volume of raw water will be fully determined by the net rainfall, irrespective of whether raw water is taken from the surface or from underground.

The advantage of groundwater is that it can (perhaps) be available at times and places where surface water is sparse. In this respect, groundwater resembles a surface reservoir, except that the water does not evaporate. From this point of view, groundwater (if available) is a safer source than surface water. In case of competition between deep wells and surface withdrawals, the surface source will run dry before the groundwater source.

Therefore, *the first right to groundwater should be given to the most important uses.* Urban supplies, rural domestic supplies, and activities with a high earning per unit of water. If such priorities cause socio-economic distortion, a fair regulation can be obtained by charging a graduated groundwater fee.

Groundwater, being a finite resource, should not be regarded as a free good. *Exploitation should be regulated.* This is because of the social value of the groundwater resource. Furthermore, drilling of deep wells is expensive, and new withdrawals can reduce the yield of other wells in the area (by lowering the groundwater table). There is a potential risk that the social value of a new well becomes negative, if this well reduces the yield of several existing wells. One way of regulation is granting (or sale) of fixed-term concessions for withdrawal of a certain amount of groundwater at a given location.

The quality of the groundwater is a matter of particular concern, because its renewal can take decades. Groundwater can be contaminated by seepage of toxic compounds (or fertilisers) from agriculture, industry, and waste disposal sites. Once contaminated, the treatment costs can be prohibitive for most uses, including public supply. Groundwater management must involve *effective prevention of contamination.* This comprises (1) good practices for use of pesticides and fertilisers, including a ban on the most severe contaminants; (2) retention of all toxic compounds at the point of origin (such as the individual industry); and (3) disposal of solid waste by means that prevent contamination by infiltration.

3.5 Environmental impact

The forces mentioned in Section 3.1 above will put a pressure on the environment of the Basin. There are three primary concerns in this connection:

- The risk of a reduced streamflow in the dry season, caused by the increased demand of water;
- the risk of an increased pollution load, caused by population growth, changed lifestyles, intensified tourism, and intensified agricultural and industrial production; and
- impact of planned reservoirs.

Figure 3.3: Sewage stabilisation ponds to serve Chiang Rai Town, under construction (mid 2000)

Ecological demand of streamflow

A certain minimum streamflow is one among several other requirements for prevention of ecological degradation (or even irreversible damage). This minimum flow - the ecological demand - varies over the year, and from one place to another. To maintain a healthy environment, the flow must be higher in the wet season than in the dry season, because the different species have annual cycles that reflect their natural habitat. For example, some fish species spawn on flood plains and rely on annual floods for their reproduction.

Sometimes, the waterlevel is critical, rather that the flow rate. For example, a target of maintaining a general minimum depth of 1 m has been suggested (in SR-11, p. 16). Also, a minimum waterlevel is required for navigation.

In the present study, a value of *1 l/s per km2 of catchment area* has been applied as an indicator for the ecological demand in the dry season. The value has been taken from a previous RID study (by Panya Consultants), the Master Plan Study for the Khao Soi Dao. There is no basis for recommending the value as a fixed standard, but its magnitude appears to be realistic. The hydrological simulations in connection with the present study show that the value has been violated in the Kok River Basin on discrete occasions in the 22-years period from 1976-97. No flow-related environmental damage has been reported from this period. This may be taken as an argument that the risk of such damage in the Basin is low if the (annual daily) minimum flow is at least 1 l/s/km2 of catchment area.

The implications of the ecological demand of streamflow is illustrated in the summaries of water balances and demands for each sub-basin that are shown in Appendix A.

Pollution load

A statistical projection of current trends has been made in connection with the pollution load modelling under the present study. Findings are summarised in Table 3.5. The figures should be regarded with caution, because the actual development will be exposed to many factors that cannot be predicted. Table 3.4 may be taken as a highlighting of the present course of development, rather than a reliable forecast of conditions 20 years from now.

The analysis points at a large increase of loadings from Chiang Rai Municipality, and a small increase elsewhere in the Basin. The supply of pollutants from urban areas will increase due to population growth and construction of sewer networks, but will decrease to the extent that treatment is implemented. The loadings from rural areas will highly depend on the land use. In Suai sub-basin, the supply of nutrients is expected to decrease significantly due to reforestation (SR-5, p. 6).

		Myanmar	Fang	Upper Lao	Lower Lao	Suai	Upper Kok	Lower Kok	TOTAL
Area (total 10565 km2)	km2	3390	1910	2084	616	436	927	1201	10565
Nominal runoff	mm/year	890	587	335	632	581	804	833	684
Nominal runoff	Mm3/year	3017	1121	698	389	253	746	1001	7226
BOD									
Domestic	t/year	617	1,532	1,039	919	257	2,503	1,682	8,549
Industry	t/year	0	18	10	1	0	4	0	33
Livestock	t/year	325	437	854	1,907	199	1,141	2,770	7,633
Non-point sources	t/year	17,795	5,943	3,812	1,959	1,481	4,116	5,105	40,211
BOD, total	t/year	18,737	7,930	5,714	4,786	1,938	7,764	9,557	56,426
Tot-N									
Domestic	t/year	89	275	185	287	42	1,122	466	2,467
Industry	t/year	0	0	369	0	0	-	0	-
Livestock	t/year	157	202	0	833	83	516	1,215	3,366
Non-point sources	t/year	2,539	1,604	909	694	246	929	1,703	8,625
Tot-N, total	t/year	2,786	2,082	1,463	1,814	371	2,567	3,375	14,458
Tot-P									
Domestic	t/year	21	78	52	99	11	418	156	834
Industry	t/year	0	0	0	0	0	0	0	0
Livestock	t/year	37	63	119	283	35	124	387	1,048
Non-point sources	t/year	192	195	105	96	22	104	230	943
Tot-P, total	t/year	249	335	276	478	68	646	773	2,825

Table 3.5: Estimated loadings in 2020 (cf. SR-5)

Environmental development issues

A variety of relevant ecological development issues has been identified. Between them, they can serve as a starting point for formulation of operational environmental development goals (cf. Chapter 4). They are listed in random order as follows:

- Preservation of a streamflow that complies with the ecological demand;
- preservation of a suitable drinking water quality;
- preservation of a desired surface water quality, including avoidance of toxic compounds (from irrigation tailwater and industry) that can affect the biosystem and contaminate edible fishes;
- prudent use of pesticides (including types of pesticides, and application practices);
- appropriate land use management, aiming at protection of headwaters, and prevention of widespread soil erosion;
- preservation of special habitats, such as wetlands and upland areas unsuited for crop cultivation;
- preservation of a desired biodiversity;

- sustainable and acceptable solid waste disposal;
- sustainable and acceptable development of tourism; and
- provision for long-term development of the groundwater potential, including strategic preservation of the groundwater quality.

3.6 Social impact

The social and socio-economic development is closely interrelated with management of water and other natural resources.

Technically, social welfare is less operational and more difficult to target and monitor than economic (or even environmental) development. The 8th national Economic and Social Development Plan has defined 39 indicators for basic social minimum needs (SR-12, p. 2 & pp. 29 - 38). Among these, 17 indicators were not fulfilled everywhere in the project area (1997 data). Some of the indicators that were not fulfilled are directly related to water and the environment (SR-12, pp. 34-35):

#15 Access to clean drinking water

#17 Safety against noise, vibrations, dust, odour, air pollution, wastewater, solid waste or hazardous waste

#27 Safety against natural calamities

In a broader perspective, the present trends indicate that immediate and medium-term socio-economic concerns in relation to natural resources management comprise

- generation of occupation outside of the agricultural sector (in order to absorb the labour surplus caused by population growth and higher production efficiency);
- generation of occupation outside of the large towns (in order to prevent excessive urbanisation);
- prevention of land degradation (including headwater protection, prevention of soil erosion, and prevention of contamination of surface water and groundwater); and
- mitigation of social impact of planned reservoirs that require re-settlement.

Socio-economic management requires application of instruments for reallocation of costs and benefits. This is one precondition (among several others) for a suitable allocation of water resources, and a suitable management of the environment, including handling of waste products. The socio-economic structure in the project area is dynamic, due to forces like the ones listed in Section 3.1. Water as a free good, historical rights of the farmers, or social power of an affluent minority, are not adequate as a basis for guiding the course of development. If so, the result is likely to be wealth and welfare below what might have been, together with a distorted distribution. Linkages must be observed and the relations harmonised among generation of wealth, generation of welfare, and the distribution of wealth and welfare. This requirement has been envisaged in the over-all national policies, as formulated in Thailand's 8th Economic and Social Development Plan (1997-2001).

In integrated water and natural resources management, such linkages can be addressed in several ways:

(1) The basic option is to define and observe primary requirements and priorities (such as drinking water quality etc).

(2) The next step is to make costs and benefits transparent to decision-makers and users, and to assure that resources are actually allocated in a reasonable way. This may involve levying partial or full user fees.

(3) A more far-reaching option is re-allocation of costs and benefits by taxes and subsidies that are unrelated to the actual direct service costs (such as *'green taxes'* or traditional redistributive taxation).

4

Integrated planning

This chapter gives a discussion of the implications of integrated planning, as compared with sector planning and thematic planning. The integrated planning is not seen as an alternative, but rather as a supplement. It may provide an interactive coordination between sector priorities and thematic concerns (like environmental protection), and can, at best, identify and manage synergies and conflicts.

The objectives of integrated planning are broader than the sector development goals. Therefore, they are more valid in an environmental or social context. At the same time, however, such comprehensive objectives are more difficult to manage. Either, they are so general that they cannot directly serve as a reference for day-to-day decisions; or they can be so comprehensive that it may be difficult to achieve the consensus about them which is another precondition for their practical application. This is why the formulation and adjustment of the objectives is an important process in itself.

4.1 Integrated planning versus sector planning

Integrated water resources management (as defined by the Global Water Partnership) is a process that promotes the co-ordinated development and management of water, land and related resources, in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems.

Hereby, the integrated planning becomes a supplement to other types of planning (which it cannot and should not replace, for several reasons): Sector planning and master planning.

The integrated planning supplies a framework for management of the many inter-sectoral dependencies that may be less visible in each sector plan. The justification for this additional planning effort is to steer the development clear of constraints, and, at best, to provide an added value to the sector plans by identifying options and opportunities that may have been overlooked because they relate to a combination of sectors rather than a single one.

Thailand has a particular tradition for integrated planning via its series of 5-years national development plans that was initiated in 1961. Particularly the first and the present, eighth plan emphasise the social dimension of economic development. Also, the environmental dimension is covered (cf. an extract attached as Appendix C). The preample to the present 5-years plan states that

> *'The planning process will also be shifted from a compartmentalised to a more holistic approach from the beginning, seeking to contribute to the whole system rather than later trying to integrate separate sectors, in order that the majority of the Thai people can realise genuine benefit from this development plan.'*

The integrated water and natural resources planning can be confined to an area that is smaller than the (often nation-wide) sector plans. As exemplified by the present study, the planning area can even intersect the ordinary administrative province boundaries, in order to cover an entire watershed like

the Kok River Basin. From this point of view, the integrated planning of natural resources applies *'natural'* boundaries rather than *'social'* or *'economic'* ones.

A simple, yet practical concept for integrated planning is outlined in Figure 4.1.

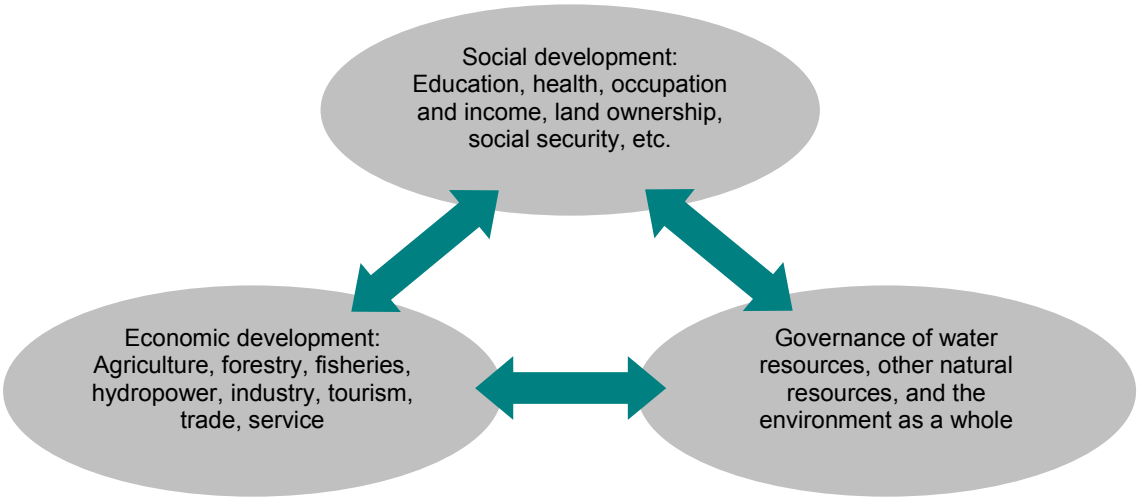


Figure 4.1: Components of integrated planning

The basic justification of the integrated planning is that it must, in some way, *add to the value of the sector planning.* The integrated planning is not an alternative, but a supplement. It must contribute to strategies for development that are better, by being more comprehensive and more consistent, than what can be achieved on the basis of the various sector plans alone.

4.2 The Plan and the planning process

The Plan

A *'Plan'* as such is merely a starting point for development towards the stated goals.

The instantaneous course of action outlined by the Plan is determined by the aims of the day, the opportunities of the day, the challenges and constraints of the day, and the knowledge and understanding of the day. All these will change continuously, and the Plan must adapt accordingly.

Therefore, the planning process (or management process) is as important as the Plan itself.

One of the most important environmental and social development plans ever made was, for that very reason, not called a plan, but an Agenda (Agenda 21). The word *'agenda'* reflects the incomplete and transient basis for decisions that need to be taken in any case, with or without applying a long-term objective as a reference.

The Plan, as such, serves the following important purposes:

- To provide an opportunity and an incentive to stakeholders to formulate and agree on transparent joint development objectives;
- to function as an instrument for delegation of authority for implementation. Once the goals and the related strategies have been defined, the practical work can be entrusted to agencies and

authorities that are in an appropriate position and that have adequate resources, abilities, and influence to pursue the goals. For example, the competence can be de-centralised and shared with NGOs;

- to appear as an initial milestone in the planning process;
- to serve as an official justification for initiation of activities and projects that aim at achieving its goals; and
- to provide a reference for monitoring of progress.

The planning process

The planning (or management) process has the following purposes:

- To formulate and re-formulate development objectives that are agreed between stakeholders, hereby maintaining, extending and consolidating the shared priorities among the stakeholders;
- to achieve such development objectives;
- to compile knowledge and to incorporate this knowledge in continuously improved strategies; and
- to stimulate, monitor and guide the course of development in an inter-active way.

Components of the process are illustrated in Figure 4.2. In this figure, the process is regarded as a cycle of activities that overlap: Formulation of objectives agreed between the stakeholders, development of strategies, and implementation. In the process, knowledge will be generated by the gained experience, which can in turn serve as a basis for a new cycle. Figure 4.3 illustrates inputs and outputs of the process.

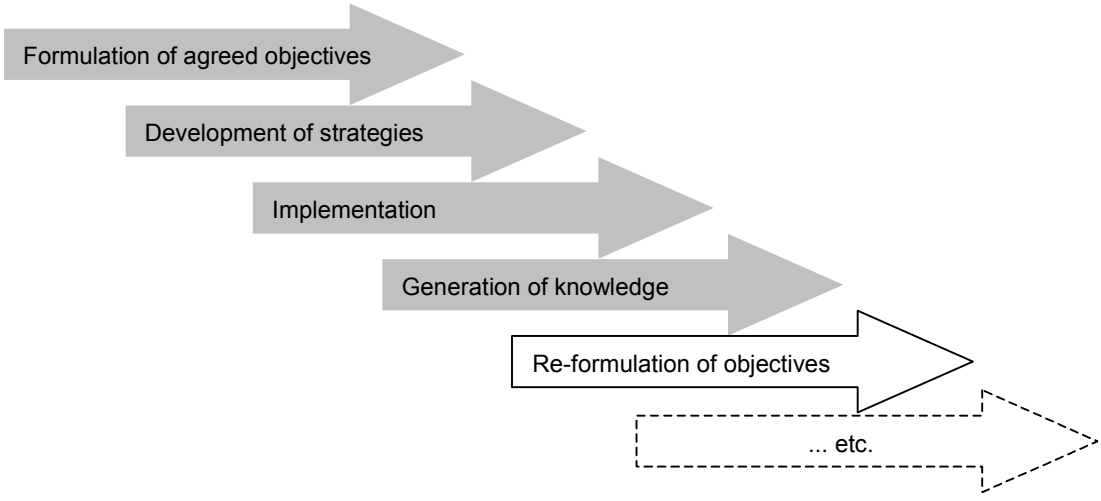


Figure 4.2: The planning cycle

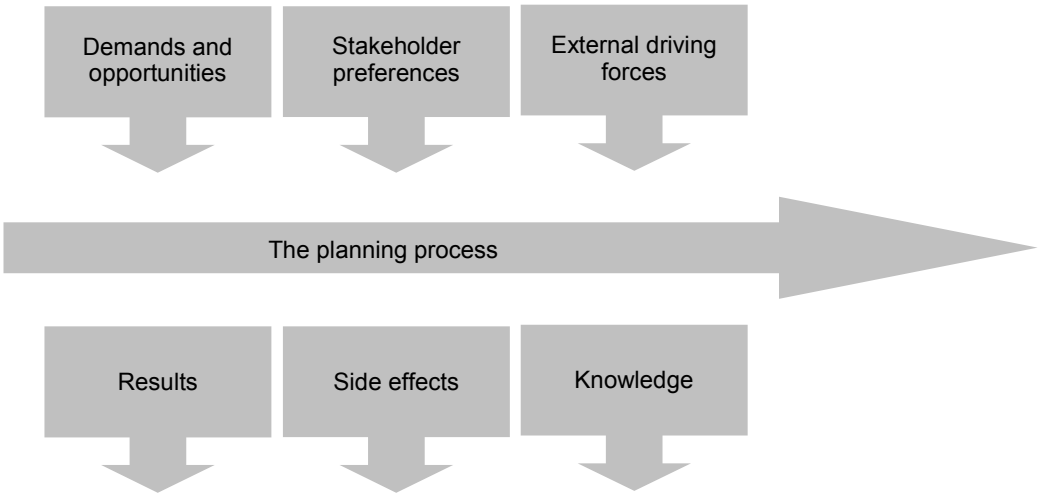


Figure 4.3: Inputs and outputs of the planning process

Formulation of objectives

The most important part of the integrated planning process is the formulation and occasional re-formulation of *clear, agreed, long-term development objectives.* This is a process in itself. While it may be easy to draft such objectives, it may be time-consuming and intricate to achieve some practical extent of consensus about them among the stakeholders.

Once agreed on, the objectives can serve as the starting point for policy formulation and implementation. In this connection, the objectives serve as a reference for delegation of responsibility from the decision-makers to the specialists.

One thing is to agree on a goal - another, and more difficult thing is to reach it. But the exercise of considering, with an open mind, the ultimate target for development, can be useful in itself.

It is important that the objective reflects a vision that is at least partly independent from short-term constraints. The question of *'where do we want to go'* should not become entangled with the (equally relevant, but different) question of *'where are we able to go'.* The plan should be more than merely a projection of present trends.

Challenges to the planning process

The planning process is exposed to a number of *'challenges'* (or important requirements) that can eventually affect its success. They are listed in the following tables, where a distinction has been made between context-related challenges, process-related challenges, and challenges related to the institutional setting and information flow.

In general, these challenges are not decisive. Rather, they represent aspects that can either accelerate or delay the process. In turn, the planning process can affect several of the aspects listed, and can, possibly, bend them in a positive way. At best, a positive interactive development can be generated.

The 'hard' challenges are summarised in Table 4.4. Between them, they determine the feasibility and the usefulness of the integrated planning.

• Conflicts of interest, e.g. upstream/downstream, or between sectors, or between national/provincial/local priorities
• Legislation (water law) not yet in place, local administration not yet fully implemented

Table 4.1: Context-related challenges

• Unstructured and dynamic allocation of social power blurring priorities and decision-making, and affecting implementation and monitoring; or arbitrary activation/de-activation of goals, and abruptly shifting priorities during the (consensus-oriented) decision process
• Incomplete consensus among powerful stakeholders, and lack of tools for reconciliation
• Incomplete availability of valid and practical indicators for monitoring
• Keeping momentum in the planning process

Table 4.2: Process-related challenges

• Low decision-making capacity, for example due to lack of consensus among stakeholders
• Deviating institutional orientation, capacity, and capability, or unclear delineation of authority
• Incomplete data and information, or poor quality of data and information
• Inadequate information exchange among stakeholders

Table 4.3: Challenges related to institutional capacity and information flow

• Joint orientation among stakeholders, including
• (i) consensus on sector objectives and strategies, and
• (ii) acceptance of rules and/or practices for water sharing and water quality
• Active support from stakeholders
This requires in turn
• Added value of integrated planning (as compared with sector planning)
• Active participation by stakeholders in goal formulation and plan implementation
• Balance between stakeholder interests
• Adequate information flow

Table 4.4: Success criteria

4.3 Integration of sector goals and strategies

The integration of different sector goals and strategies is an iterative, dynamic process. It aims at achieving a practical consensus among key stakeholders, as a precondition to successful implementation.

That the consensus is 'practical' means that it must be adequate, but at the same time perhaps incomplete and temporary. One of the stakeholders may have an attitude like *'I don't agree, but this is not important to me, so I don't object'*. This can be adequate for a practical consensus, and many decisions are taken on such a basis, because a full, true consensus can be impossible to achieve. But there is a risk that a dormant difference of opinion can be activated at some later stage.

Over-all development goals are relatively easy to formulate and agree on. This is because they reflect, in general terms, good political intentions, which few people would object to. The difficulties appear when the over-all goals are spelled out in operational strategies with visible consequences for individual stakeholders and costs to be covered from finite public budgets.

Sometimes, conflicts of interest between sectors can be sorted out by agreeing on objectives at a higher level of integration, or by applying a longer time scale. This involves formulation of a detailed long-term vision for the Kok River Basin.

Examples of actual or potential inter-sectoral linkages are given in Table 4.5.

• The groundwater quality can deteriorate (due to seepage of pesticides from agriculture, or other pollutants). Hereby, a valuable resource can be lost. Groundwater pollution can remain for decades. This is critical if the demand of groundwater escalates, for example for supply of the town of Chiang Rai
• Tailwater from irrigation and return flow from fish farms can carry pollutants that can reduce the downstream fish stock and the fisheries yield, both in the river and in fish farms. Irrigation tailwater and industrial discharges can contaminate fish caught for human consumption
• Soil conservation is related to land use and land use practices, which are in turn related to land ownership
• Disposal of untreated sewage from Chiang Rai Municipality is reported as a problem today. This disposal will inevitably escalate in the future, due to population growth and development of sewer systems. Sewage treatment must be introduced, but this is not without side effects. Apart from the land requirements and the costs, the disposal of sludge represents a potential pollution risk
• Disposal of solid waste requires prudent management. Quantities will escalate, and the risk will increase of contamination of the waste by hazardous compounds from industry, hospitals, etc.

Table 4.5: Examples of inter-sectoral linkages

4.4 The water resources dimension

The water resources dimension of integrated planning may be divided into the following types of implementation strategies:

(i) structural measures; and

(ii) non-structural measures, which may in turn be divided into

(ii.a) development of cultivation routines, and operation and maintenance procedures for irrigation systems; and

(ii.b) regulation by fees and subsidies.

The reason for this classification is the involvement of different line agencies, and the different time scales for viability. For example, the general technological development will continuously offer new options for improved water efficiency. As another example, levying a water fee is hardly acceptable today, but will most likely be implemented some time within the next few decades.

While the surface water resources are fully utilised, the groundwater resources (if they exist) are almost undeveloped. This offers a particular opportunity for regulation of groundwater abstraction.

4.5 The environmental dimension

Implementation of the environmental dimension of integrated planning can be supported by making a distinction between different categories of strategies.

These could be:

- Basic immediate priority requirements that are recommended for unconditional enforcement (such as groundwater quality, and strict management of toxic and hazardous compounds);
- 'win-win' strategies that can be implemented in a way so that several stakeholders gain, while no stakeholders loose (such as, perhaps, improved water utilisation efficiencies, solid waste separation schemes, sustainable commercial forestry, or development of reservoir fisheries or ecotourism);
- desired, medium-term developments that are valuable, but perhaps subject to financial constraints (such as reforestation programmes, or development of reservoir fisheries); and
- strategic activities (for example awareness-building and capacity-building that can facilitate implementation later on of measures such as *'green taxes'* that are not viable today).

The idea with the functional separation of strategies is that one viable strategy may proceed, without impediment by activities or other strategies that are less acceptable to key stakeholders. This requires that each strategy is 'self-supporting' in relation to the over-all development goals.

Obviously, 'win-win' strategies can reasonably be expected to be easy to implement, provided that some can be found. In this connection, it may be argued that clear and transparent environmental regulation of new industries in itself may be regarded as a 'win-win' strategy. Any investor wants a good knowledge about earnings, costs and risks, and few serious investors would trade a small saving from lax regulation for a risk of intervention later on. While it may sometimes be expensive for an existing industry to reduce its water consumption or its waste production, at least within a short time frame, it is often a small cost only for a new industry. This is because the new industry can design its procedures and equipment accordingly from the beginning, making use of recent technologies.

4.6 The social dimension

The social dimension is the third cornerstone of integrated planning. It represents a means and an end at the same time. According to national development policies, reflected in the current 5-years plan, social development is the ultimate objective of economic development:

> *'In past plans, the national economic and social development concept has largely been based on the acceleration of economic growth utilising comparative advantages in terms of natural resources and low-cost labour to produce goods and services for export. This development strategy was suitable for the needs of the time and consistent with the economic and social situation of the country. However, successes in economic growth and material progress to date have not meant that all Thai people are enjoying greater wealth and a substantially improved quality of life. On the contrary, rapid economic growth has had negative effects on Thai culture, traditional ways of life, family, community and societal values. The impact on natural resources and the quality of the environment has also given cause for serious concern.*
>
> *Genuine sustainable development for Thailand in the future will depend on the degree to which the potentialities and creativity of the Thai people are strengthened and enhanced. For this reason, the Eighth National Economic and Social Development Plan has adjusted the development concept, shifting from a growth orientation to people-centred development. The state of the people is considered to be the final measure of success: economic improvement is*

treated only as a means to improve the well-being of the people rather than as the final objective of development.'

The interdependency is also reflected in the vision of MRC of an *'economically prosperous, socially just and environmentally sound Mekong River Basin'.*

The harmony and synergy between economic, environmental and social development can be pursued by integrating the social dimension in the over-all development goals, as well as in the operational targets. In connection with integrated resources management, short-term strategies for implementation comprise

- observation of basic health standards (notably for drinking water);
- fair and sustainable land use management; and
- prevention of irreversible degradation.

Long-term strategies comprise

- education and awareness-building related to sustainable resource utilisation and environmental protection;
- management of the semi-legal and illegal immigration into the project area; and
- implementation of instruments for demand regulation and redistribution of social costs and benefits in connection with supply and demand of water and other natural resources

Kok River Basin has a particular social dimension, which is related to the ethnic minorities. Their traditional lifestyles and subsistence economies are strained beyond endurance by population growth, ecological degradation related to a finite land availability, and exposure to new opportunities and regulations imposed by the surrounding society. A fair social development is a challenge to policy formulation and implementation. Obviously, education should be one element in this effort.

5

Implementation

The implementation of a plan is more than a practicality. Already in the initial stage of planning, strategies for implementation can indicate whether the plan is (1) practical and (2) useful. Both criteria should be fulfilled in order to justify the planning and the resources allocated for the purpose.

The present chapter deals with implementation aspects. It describes linkages with related planning, and gives preliminary indications on institutional arrangements. Different tools and mechanisms are introduced, as well as suggestions on pilot projects that can support the development goals, or strengthen the planning process, or both.

5.1 Goal formulation

General

The main challenges of integrated management of water and the environment have been described, in general terms, by the Global Water Partnership. They are listed in Table 5.1.

- Securing water for people
- Securing water for food production
- Developing occupations that are less water-consuming and less waste-producing
- Protecting vital ecosystems
- Managing variability in time and space
- Managing risks, such as droughts and floods
- Creating popular awareness and understanding
- Forging the political will to act
- Ensuring collaboration across sectors and boundaries

Table 5.1: Scope of integrated management (GWP publication TAC-4, pp. 10-13)

Objective

The following double development objective is suggested for management of water resources and the environment of Kok River Basin:

An allocation of water resources that is
physically feasible,
socio-economically suitable, and
environmentally sustainable;

and

an environmental state of the Kok River Basin
complying with standards that have been agreed between the stakeholders.

That the allocation of water resources is physically feasible means that it reflects the linkages within and between different sectors, so that the water is only allocated one place at one time. That the allocation is environmentally sustainable means avoidance of undesired, irreversible environmental damage.

The formulation does not indicate that the environment should *'remain unchanged'* or be restored into *'a state that is unaffected by human intervention'.* This would be unrealistic, and presumably not even desirable. Rather, it is suggested that the state of the environment should comply with agreed standards. This reflects an intent to develop, in due course but without unnecessary delays, a practical extent of consensus about a desired state of the environment, to serve as an operational guide to development. This is elaborated in Section 4.5 below.

The development objective should be reviewed, adjusted and endorsed by the stakeholders. It should be revised from time to time, as a consequence of new external developments, new knowledge, and new social priorities.

Once endorsed, the objective can serve as a course indicator for development of water resources in the Basin. Projects and programmes that support the objective will be subject to a *'no objection'.* Projects and programmes that are clearly in conflict with the objective should be rejected. Projects and programmes where conformance is doubtful should be reviewed and adjusted as required. In case of unacceptable or unexpected conflicts, the objectives should be re-considered.

In any case, the objectives should be reviewed on a routine basis once in a while, in order to maintain their concordance with political preferences and external forces.

Planning horizon

The nominal time horizon for the planning is 20 years.

5.2 Basin planning and national planning

A practical integrated basin planning must fit into the national planning that it is part of. The harmony must comprise (1) development objectives; and (2) rules and practices for planning and implementation.

This requirement is no big obstacle, though. The national planning is already oriented towards harmonisation between sectors, and towards adjustment of sector development goals towards over-all national development policies. The 8th national Economic and Social Development Plan highlights cross-sectoral themes, such as environmental preservation (cf. the extract attached as Appendix C). The Plan includes strategies for

- rehabilitation of natural resources and environments (Part VI, Chapter 2);
- promotion of popular participation in natural resource and environmental management (Part VI, Chapter 3); and
- improving natural resource and environmental management (Part VI, Chapter 4).

The Plan is less explicit in the field of water resources management, which historically is a sensitive political issue.

It is important that instruments, routines and traditions are in place for formulation, implementation, and re-formulation, in a way that resembles the simplified illustration in Figure 4.2. Concerns and opportunities are identified not only at the central level of administration, but also at the provincial

level, and sometimes even below this level. Implementation of the strategies is shared between the levels, and an aim of decentralisation is clearly spelled out.

Instruments and practices are a necessary but not a sufficient condition for successful implementation. The national economic and social development planning, like most other plans, is exposed to highly dynamic external forces that can and do change its prospects drastically and abruptly.

A provision of particular relevance in the present context is the role of National Environment Board (NEB). As shown in Figure 2.7, NEB is placed close to the focal point where the different sector priorities are compared with each other, as a basis for formulation of coordinated national strategies. Today, the role of NEB is to participates in the screening of large projects, and other projects that either affect natural reserves or are otherwise regarded as environmentally sensitive. It might be a minor step to extend this responsibility to cover cross-sectoral implications in terms of water resources and natural resources.

5.3 Institutional arrangements

Responsibilities and authority

Table 5.2 gives a draft outline of a possible allocation of responsibilities and authority among administrative levels. The outline assumes that harmonisation of goals, and coordination of efforts within different sectors can best take place at the central level of administration, where the outlook and the professional specialist expertise are located. Identification of concerns and opportunities, and implementation of measures to achieve the goals may best take place at the local level of administration, where the insight and the knowledge about specific circumstances are located.

At the same time, the project area is located within the Lower Mekong Basin. This means that certain interventions are covered by the 1995 Mekong Agreement between Cambodia, Laos, Thailand and Vietnam.

It is noted that Kok River Basin is shared between two provinces. This is also the case for several of the sub-basins (cf. Appendix A).

Coordination between agencies

Liaison, exchange of information, and inter-active coordination between the various agencies will be a main challenge in connection with integrated management.

The formal coordination undertaken by NESDB and other organisations under the Prime Minister's Office is necessary, but indirect, and therefore not sufficient for a fruitful dialogue. This will require some direct communication between the agencies. This question is particularly important in connection with water resources management, but perhaps less urgent in connection with environmental management, where the responsibilities are mainly allocated within a few organisations under the same ministry. On the other hand, there are close linkages between water resources and the environment, and one cannot be effectively managed independently from the other.

Level	Function	Organisation
Regional (Cambodia, Laos, Thailand and Vietnam)	Notification or endorsement of water uses and diversions, according to the 1995 Mekong Agreement Operational rules for water sharing among member countries, and for water quality, are in preparation	MRC, TNMC
National	Consistency (with regard to water resources and environmental impact) between sector plans (prepared by different ministries), and between sector plans Harmony between sector goals and integrated development objectives	NEB (with reference to NESDB)
	Formulation and re-formulation of integrated development objectives Development of tools and instruments for implementation (guidelines etc). Monitoring of progress	OEPP (as coordinator), in consultation with other line agencies
	Planning of individual sectors and themes National formulation of basic, compulsory requirements Implementation	Various line agencies: OEPP, DEDP, Dept. of Mineral Resources, RFD, RID, EGAT, Min. of Public Health, PWA, RDP, etc.
Provincial	Identification of priorities, concerns and development opportunities Implementation	Provincial administration, NGOs
Local	Identification of priorities, concerns and development opportunities Implementation	Amphoe, tambon, NGOs

Table 5.2: Administrative levels of plan implementation

A Kok River Basin Committee

If so desired, the required liaison can be maintained by an inter-agency *'Kok River Basin Committee',* which could build on the Steering Committee for the present project. Draft Terms of Reference for such a committee are indicated in Table 5.3.

There will be an overlap between such a committee and the Thai National Mekong Committee (TNMC) under the Prime Minister's Office. This is because TNMC serves as the national focal point for the comprehensive plans, programmes and projects implemented by MRC for the entire Lower

Mekong Basin (of which Kok River Basin is a part). (Examples of such plans, programmes and projects are given in Section 2.7 above). The overlap cannot be avoided. It should not cause duplication of efforts, provided a suitable exchange of information.

The Committee should probably not in itself implement any of the projects or programmes that it may initialise or coordinate. This is better done by line agencies, authorities or NGOs, as relevant from case to case and in accordance with the capacity and expertise required in the specific context. The same is the case for impact analyses and public hearings. The Committee can point at a need, and make recommendations, but should not execute such activities.

Participation

Chiang Rai and Chiang Mai Provincial Administrations; line agencies (OEPP, DEDP, RID, RFD, ...); TNMC

Duties

1 To formulate development goals for water resources and the environment in Kok River Basin; and to re-formulate such goals from time to time as required. This should be done in a dialogue with the stakeholders, and in harmony with the national development goals

2 To exchange information about present and planned projects, initiatives and developments in the Kok River Basin that can affect the water resources and/or the environment

3 To review planned projects, initiatives and developments in the Kok River Basin with regard to (i) their consistency with each other (in terms of resource utilisation); (ii) their compliance with the stated development goals; and (iii) their general implications on water resources and the environment

4 To identify, initiate, support and/or coordinate pilot projects and other efforts that can support the development goals. (Implementation will normally take place outside of the Committee)

5 To initiate and support public participation in connection with water resources and environmental management in Kok River Basin. (Implementation will normally take place outside of the Committee)

Reporting

Each year in July, the Committee is expected to submit a short statement to NEB and NESDB about projects, initiatives and developments planned in the Kok River Basin. The statement should evaluate whether these are consistent, and in accordance with applicable development goals. The statement should include a small location map

Table 5.3: Draft Terms of Reference for a Kok River Basin Committee

The Committee could meet (at least) once per year, at a time that allows for making a timely statement in connection with the processing of the annual national budget (which controls implementation of the sector plans of the various line agencies). This statement should comment on planned projects, initiatives and developments in the Kok River Basin, whether these are consistent in terms of resource utilisation, and whether they comply with the stated development goals. The statement should be submitted to NEB and NESDB.

That projects comply with the stated development goals can mean that they are advised against if they violate the ecological demand of streamflow.

The consistency analysis can conveniently be based on analyses reported under the present study, and on hydrological modelling to be made under the MRC Water Utilisation Programme (where TNMC will be heavily involved). Otherwise, agencies (or private developers) who propose a scheme can be requested to prove its consistency, in the same way as they can be requested to prepare an Environmental Impact Assessment.

The Committee cannot impose sanctions (except advising against a project), but it is believed that a recommendation from the Committee will be a strong incentive.

A draft agenda for an annual meeting is indicated in Table 5.4.

1	Endorsement (or revisal) of development goals
2	Information about progress of the MRC Water Utilisation Programme, the Mekong Basin Development Plan, and other regional or national projects and programmes
3	Review of planned interventions that can affect the water resources and/or the environment in Kok River Basin (aiming at a formal statement to NEB and NESDB)
4	Discussion of planned or recommended non-structural development efforts
5	Discussion of planned or recommended pilot projects or other efforts to support the development goals
6	Discussion of the need of public hearings or consultations

Table 5.4: Draft agenda for annual meeting of the Kok River Basin Committee

5.4 Stakeholder participation

All experience shows that a comprehensive participation by stakeholders is one among several criteria for an effective progress towards the development objectives. Public participation can build public awareness and orientation towards the agreed goals, and this can be one of the most important forces during implementation.

During formulation of the plan, stakeholder participation can be achieved at four stages that represent progressive levels of interaction (cf. MRCS Guidelines of April 1999):

(i) Information gathering: Collection of information from the stakeholders about social, cultural, economic and political concerns, opportunities and priorities

(ii) Information dissemination: Supply of information to the stakeholders about intents, preliminary objectives, strategies, options and constraints

(iii) Consultation: Dialogue with the stakeholders about needs and preferences

(iv) Endorsement: Request for the stakeholders' full or incomplete accept of development goals and strategies for implementation

It may be argued that such participation should be extended to all stages in the planning cycle, but there are two stages where participation is particularly important. One is the *goal formulation,* where the development objectives are drafted, modified and agreed on. Another is the actual *implementation* of the various strategies and actions. In comparison, the formulation of strategies, rules and criteria to support the development objectives may well involve a substantial extent of professional expertise that may be difficult (or even counter-productive) to share with the general public. On the other hand, stakeholders can contribute valuable knowledge about opportunities and practical constraints that can be incorporated into the strategies in order to facilitate their implementation (or even assure their feasibility).

The process should proceed through the public representative institutions (the provincial governments and the tambons). The active involvement of these institutions is a mutual advantage that can strengthen the institutions and the planning process at the same time.

The participation can be direct and/or indirect. In many cases, NGOs are in a particular position to supply knowledge and experience about concerns, priorities and constraints that can affect implementation of the plan.

Specific suggestions on implementation of stakeholder participation are given in Section 6.5 below.

5.5 Application of models

In the present study, different numerical computer models have been used as planning tools. The applications are described in the following reports: SR-2, Rainfall-runoff modelling; SR-3, Water resources modelling; and SR-5, Pollution load modelling.

The models were used for the following tasks:

- Conceptualisation, validation and projection of data and knowledge about land use, the hydrological cycle, and pollutant loadings;
- GIS analysis of baseline conditions, projections and scenarios;
- consistency analysis of scenarios (including hydrological and environmental feasibility of proposed intervention);
- examination of benefits and effects; and
- impact prediction for individual schemes and entire scenarios.

The applied models are listed in Table 5.5.

In the present study, there were two particular advantages of applying these models: (i) Their set-up and calibration highlighted the consistency and quality of the basic data, and facilitated the generation of complete data sets by combining data and information from measurements, literature and experience. (ii) The models provided projections and impact predictions that might not be correct in every detail, due to incomplete data, but which were still detailed and consistent. It is believed that the relative accuracy of the modelling results is adequate for many planning purposes, including ranking of schemes, even if the absolute accuracy may be imperfect.

NAM A rainfall-runoff model that describes exchanges between (1) the atmosphere; (2) a snow cover (if any); (3) surface storage; (3) root zone storage; and (5) the groundwater. Among the transport mechanisms are rainfall, evaporation, evapotranspiration, overland flow, infiltration, capillary flux, groundwater flow and abstraction. Calculations are made with a fixed time increment, often 1 day, and often over simulation periods of many years
LOAD A steady-state pollution load model that is coupled with the ArcView GIS software. It calculates point sources and non-point sources of pollution, as generated by for example agriculture, industry and surface runoff. Input to the model comprises information about population, livestock, industries, land use, climate, vegetation, and sewage treatment and disposal. The routing of the pollutants to the main watercourses is determined from a digital terrain model of the Basin. Output from the model is spatial distributions of pollutant loads, and their decay and accumulation in the receiving watercourses
MIKE BASIN A tool for modelling of river basin networks for integrated water resources planning and management, based on a customised ArcView GIS graphical user interface. The model describes the river network and the water allocation in terms of supplies, storages, withdrawals and diversions. Input to the model comprises time series of catchment runoff, reservoir operation, and prioritised water demands. Output comprises time series of flow in the main rivers, and the water allocated to various users

Table 5.5: Models applied in the present study

Other types of models are available for integrated river basin planning, for example for examination of compliance between actual and acceptable ecological consequences, or for prediction of economic effects. Also, more comprehensive variants are available of models similar to the ones applied. In the future, GIS tools will become even more powerful for impact prediction and scenario analysis.

A different category of models is available for automatic optimisation of for example water allocation or economic benefits. These models are regarded as less useful as practical tools, because they are not well able to reflect the reality of society. For example, this type of models might well point at an unrealistic and politically unacceptable downgrading of entire areas or sectors.

In the continued planning process, models can be used for incorporation of new data and knowledge for updating of the planning basis, for example once a better knowledge is available about the groundwater resources in the planning area. Also, the basic runoff pattern has been changing over the last decades, and may change further in the future, due to mesoscale rainfall fluctuations or changed land use. The effects of such changes on the water availability can be examined by modelling.

Furthermore, the models can provide fast and consistent comparisons between new development scenarios.

Finally, the changes in the basin can be conceptualised by modelling, for the purpose of monitoring of the joint effects of natural changes and human intervention. From this point of view, the results resemble economic balance accounts that are made at regular intervals.

5.6 Projects

Implementation of the plan can be promoted by interaction with relevant project activities.

The projects have several objectives. One is direct, namely to support achievement of the development goals. Another is indirect, namely to sustain and enforce the planning process, by making it visible and attractive. A third objective can be to serve as pilot projects, testing the viability of possible solutions to the complex problems in connection with the planning.

The projects can from case to case be small-scale, suited for completion within a reasonably short time, and within a limited budget. They can comprise extension services, awareness-building, development of new skills or new knowledge, or they can serve as demonstration projects for new technology.

The projects, once identified, may be funded from a variety of sources, and implemented by a variety of agencies and organisations, including the private sector.

Some project ideas are listed in Appendix E. These ideas are largely independent from each other. They can be implemented separately, if so preferred.

5.7 Monitoring

Monitoring is required in order to keep the planning process on the right track. Apart from changes brought about by the planning itself, numerous other changes will appear. These can affect both the validity of the development objectives, the various sector goals, the supplies, the demands, and the consequences of different courses of action. Even if there were no changes at all, an improved knowledge can in itself put the planning in a new perspective.

There are different categories of monitoring:

- Field monitoring of hydrological, chemical and biological parameters, like rainfall, streamflow, groundwater, environmental indicators, etc.;
- monitoring of demand of water and sewage loadings from towns, industry and agriculture;
- monitoring of land use; and
- socio-economic monitoring of demography and development indicators (like the NESDB indicators for basic social minimum needs).

A large part of this monitoring is in progress today under various authorities. In some respects, however, the monitoring is incomplete. For example, little is known today about groundwater availability or groundwater quality.

An important objective of the monitoring is to extend the knowledge base for over-all system descriptions like the ones prepared in connection with the present project. Better knowledge will allow for more accurate estimates of (for example) the availability of groundwater, or the ecological demand of surface water. This will in turn improve the analysis of various strategies for water allocation.

Another important objective is an early identification of threats, while there is still scope for mitigation, or of new opportunities, while they still exist.

6

Management plans and guidelines

A distinction can be made between different levels of plan implementation and related documentation. The highest level is formulation of goals and policies for nationwide development, and, in turn, development of the particular river basin. The goals can be independent of short-term (financial or technological) constraints. This level sets the over-all course of action, and represents the question of *'where we want to go'*.

The next level is the derived strategies and policies for practical implementation. The strategies and policies can be formulated in management plans. At this level, more attention should be given to immediate practicalities. This level represents the question of *'what to do'*.

The third level is the detailed procedures and routines for implementation. These can be specified in administrative guidelines, which should preferably be fully operational. This level represents the question of *'how to do what we want to do'*.

The present chapter gives an outline of scope and structure of management plans and guidelines for some environmental key disciplines. It is intended as a starting point for preparation of detailed plans and guidelines.

6.1 Purpose and contents of management plans and guidelines

Management plans

Management plans are intended for making thoughts clear about how to reach a goal. Normally, the governing set of development objectives (or policies) has been established beforehand, and perhaps in a different context. Even if so, the management plan can highlight the implications (for example the costs) of the policies, and will sometimes point at a revision of the policy, in order to make it practical.

A management plan, if clear and operational, is well suited as a tool for coordination between different agencies, including delineation of interfaces, so that gaps and overlaps of efforts can be minimised.

The plan can, as relevant from case to case, comprise:

- Development objective(s);
- a listing of issues, options, and constraints, emphasising basic (compulsory) requirements and priority concerns;
- an outline of the administrative framework: *'Who does what?';*
- proposed actions;
- supportive activities and pilot projects; and

- an implementation plan, with indicative budget and time schedule for key actions.

Guidelines

Guidelines have several good purposes. They can support a consistent and transparent approach, where this is desired, for example in connection with distributive administration (of groundwater abstraction permits, sewage discharge permits, etc), where the public will expect a fair and equal management practice. In other cases, a consistent and transparent approach is required for achieving an acceptable data quality, for example in connection with long-term monitoring programmes, where the work is carried out by a number of different persons over a long period of time.

Guidelines can be a tool for delegation of authority, for example from central to local administrative bodies. And they can serve as a vehicle for a gradual development of good practices, if they are revised occasionally on the basis of experience gained from actual applications.

Guidelines must be as brief as ever possible. They can, as relevant from case to case, comprise

- A summary of the related policy;
- a legal reference, and allocation of authority;
- description of basic (compulsory) requirements, in operational terms (reflecting the priority concerns of the management plans);
- description of preferred (but not compulsory) requirements, in operational terms if possible;
- detailed step-by-step routines; and
- a glossary

6.2 Water pollution control

Reference and basis

Eighth Economic and Social Development Plan (Part VI, Chapters 1, 2 and 4, cf. Appendix C)

The Enhancement and Conservation of National Environmental Quality Act (1992)

SR-4, SR-6 and SR-9

Issues, options and constraints

1 The water quality and the aquatic ecosystems are exposed to the combined effects of two threats: (i) The risk of a reduced streamflow in the dry season, caused by the increased demand of water; and (ii) the risk of an increased pollution load, caused by population growth, changed lifestyles, and intensified tourism, agricultural and industrial production

2 Present and future pollution sources comprise point sources (domestic loadings, industries, and livestock), and non-point sources (diffuse loadings from agricultural areas etc). The actual loadings vary from place to place and from one season to another, depending on the sewage disposal, the applied agricultural practices, and other aspects

3 Today, there are no sewered areas at all in the basin, and no treatment plants have been established

4 Industries are typically processing plants for fruits and vegetables, or noodle factories. They produce mainly organic sewage. Most industries are located around Chiang Rai, and in the Fang and Upper Lao sub-basins

5 No information is available about loadings other than BOD, nutrients and bacteria. It is not known whether heavy metals, chlorinated hydrocarbons and other serious pollutants are released to the environment within the project area

6 Loadings from agriculture are influenced by (i) a prudent use of pesticides (including types of pesticides, and application practices); and (ii) appropriate land use management, aiming at protection of headwaters, and prevention of widespread soil erosion. Loadings from industries and hospitals (other than BOD and nutrients) should be controlled at the source

7 Waste disposal sites are located far from streams and rivers, and currently, they are not expected to cause any significant pollution of surface waters. Potentially, waste disposal sites can contaminate the groundwater by seepage of toxic compounds

Priority concerns

8 To ensure access to safe drinking water to the entire population

9 To prevent any release of toxic compounds (like heavy metals or chlorinated hydrocarbons) to the environment, notably including surface water and groundwater

10 Preservation of a groundwater quality that meets with drinking water standard

Practicalities

11 Successful implementation is subject to funding, which in turn is subject to cost recovery. This can be achieved via a user's fee for full or partial coverage of capital costs, operation and maintenance

12 Implementation can partly be entrusted to private companies (which can be owned by the public, if so preferred). This has the potential advantage of more freedom of operation (unrestrained by public budgetary procedures), and could in some cases facilitate supply of capital

13 Monitoring of surface water pollution can be directed towards the sources of pollutants: Sewage discharges from towns and industries, and irrigation tailwater

14 Contamination of edible fishes should be monitored as a key impact indicator

15 Sewage disposal should be comprehensively regulated, so that some permit be required for any significant disposal from towns and industries

16 Activities that are characterised by a particular risk of pollution should be regulated. Such activities include certain industries, duck farms and full-scale aquaculture. The regulation can comprise compulsory EIA, and any discharges and emissions being subject to prior permit. Disposal of sewage and solid waste must be explicitly approved from case to case. The regulation should initially comprise new enterprises (that can presumably adjust to regulation without prohibitive costs). In order to attract investment, it is decisive that the regulation be transparent, objective and long-term. In return for the regulation (and for complying with it), the enterprises should enjoy a protection against new claims, at least for a suitable span of years

17 Good agricultural practices should be encouraged. A good general understanding should be built about the environmental risks related to soil deterioration and use of pesticides

6.3 Solid waste management

Reference and basis

Eighth Economic and Social Development Plan (Part VI, Chapters 1 and 2, cf. Appendix C)

SR-10

Issues, options and constraints

1 The total production of solid waste in the project area is estimated at 32,800 t/year (1996). The highest contributions are from Chiang Rai and Chai Prakarn. In addition, around 230 t/year of infectious waste is estimated to be produced by hospitals and clinics in the project area

2 In general, the disposal of solid waste is under pressure, because the quantities escalate due to urbanisation and changed lifestyles. At the same time, disposal practices are not in place, or disposal routines and facilities (like incinerators) are in need of upgrading or restoration

3 Domestic waste and toxic, infectious or otherwise hazardous waste impose different pollution risks and disposal requirements. The two categories should be segregated at the source and handled separately

4 Management should include non-structural measures. The public should be encouraged to Reduce, Reuse, Recycle and Repair the waste

Priority concerns

5 To prevent any occurrence of toxic compounds (like heavy metals or chlorinated hydrocarbons) in surface water and groundwater

6 Preservation of a groundwater quality that meets with drinking water standard

Practicalities

7 Successful implementation is subject to funding, which in turn is subject to cost recovery. This can be achieved via a user's fee for full or partial coverage of capital costs, operation and maintenance

8 Implementation can partly be entrusted to private companies (which can be owned by the public, if so preferred). This has the potential advantage of more freedom of operation (unrestrained by public budgetary procedures), and could in some cases facilitate supply of capital

9 Toxic and hazardous waste should be strictly separated from general urban waste at the source of origin, and should be handled and disposed of separately

10 The pilot project on waste separation in Chiang Rai is stalled. This is unfortunate, because waste separation is a prudent (and perhaps necessary) strategy. The efforts should not be shelved, but should be considered for re-implementation, based on the gained experience about the reasons for the lack of success so far

11 Re-cycling should be encouraged, for example by public campaigns, and by economic regulation (fees and green taxes). Such policies should target (1) the general public; and (2) manufacturing and industries

12 Adequate land for waste disposal should be identified as early as possible

6.4 Natural resources and environment conservation

Reference and basis

Eighth Economic and Social Development Plan (Part VI, Chapters 1, 2 and 4, cf. Appendix C)

The Enhancement and Conservation of National Environmental Quality Act (1992)

The Groundwater Act (1997)

The Community Forest legislation

SR-1, SR-7, SR-8 and SR-11

Issues, options and constraints

1 The Kok River Basin is characterised by stressed ecosystems, distorted water yields caused by deforestation, soil erosion, landslides and downstream sedimentation, and, in turn, a reduced soil fertility caused by soil erosion and leaching of nutrients. Visible effects are lack of water in the dry season, lowering of the groundwater table, and increased floods in the rainy season

2 The major part of the project area is influenced by human activities. This is obviously the case for the agricultural farmlands, but even the upland forest areas largely appear as disturbed, encroached, partly cultivated, or recently re-planted. The forests have been under strong pressure for many decades, being felled for timber and for expansion of agricultural land. Today, the status of remaining forests is at *'caution level'*

3 The development of Kok River Basin is exposed to several external driving forces. These are external determinants, or causes in cause-effect relationships that affect the Basin and its water resources, and hereby, directly or indirectly, the course of its development. Between them, these forces seem to point at three needs: (i) A need of change (or to adapt to changes); (ii) a need of higher product value per unit of water; and (iii) a need of sustainability

4 While the surface water resources are fully utilised, the groundwater resources (if they exist) are almost undeveloped. This offer a particular opportunity for regulation of groundwater abstraction

5 Groundwater is abstracted for domestic and industrial supplies. Hand pump wells for small-scale supplies in rural areas have been established in many places by OARD, PWD and Department of Mineral Resources. Apart from many small industries, 10 larger industries (producing canned or pickled fruit and vegetables) operate their own groundwater wells. The supply to the town of Chiang Rai is based on surface water

6 Groundwater yields are generally characterised as 'high', and no shortages have been reported. There is no information available about the size and distribution of the groundwater resources

7 Groundwater management must involve *effective prevention of contamination.* This comprises (1) good practices for use of pesticides and fertilisers, including a ban on the most severe contaminants; (2) retention of all toxic compounds at the point of origin (such as the individual industry); and (3) disposal of solid waste by means that prevent contamination by infiltration

8 It is expected that piped supply will be extended to more people in the future. The possibility exists that groundwater will become more common as a raw water resource for domestic supply

9 Today and in the future, the agricultural sector is by far the largest water consumer in the basin. Existing irrigation schemes cover a total area of 675,460 rai (1081 km2). The schemes are either diversion schemes or pump irrigation schemes. All are based on surface water

10 Generally, the rivers do not seem to be exposed much beyond their assimilative capacity in terms of BOD, nutrients or bacteria, although increased levels have been measured at places (for example immediately downstream of Chiang Rai). There is a fair diversity of fishes, vegetation, plankton and invertebrates, and the fisheries yield is fair. Only a few measurements have been

made of pesticides in the aquatic environment, and no information is available about contamination of fish caught in the rivers

11 There are three mini-hydropower plants in the project area. All are located in the Fang sub-basin. Their joint capacity is 8.7 MW, and their joint yield is 30 GWhours per year

12 Two hydropower schemes are planned: (1) Nam Kok hydropower project (in Myanmar) (storage volume 3,033 Mm3); and (2) Upper Fang multi-purpose project. If the Nam Kok project is implemented, it will cause a general, positive change in the dry season water availability in the Upper and Lower Kok sub-basins. There is scope for an additional (although moderate) development of hydropower in connection with some of the planned irrigation reservoirs. If energy prices will escalate over the next decades, there will be a strong motivation to implement schemes that are feasible or nearly feasible with today's cost-benefit ratio

13 Since 1989, there has been no commercial forestry in the project area, in spite of forests covering 47 percent of the project area. This is because the forest areas are in a state of restoration, following over-exploitation in the past. The restoration process is supported by a general ban on logging

14 In the long term, there is a clear scope for commercial forestry. Once restored, and with proper management, a part of the forest area will become an important commercial asset

15 The major wetlands in the project area are Nong Luang and Nong Wiang. These are partly regulated by structures, and are fairly influenced by human settling and utilisation. Their ecosystems and biodiversity are not well known. They are used as water sources and for fishing. Some informal restrictions on fishing and hunting have been self-imposed by the local communities

16 More than a hundred fish species are reported in the project area, including several economic species. Some species migrate between the Mekong and the Kok River Basin, where they breed. The yield is relatively low. The standing stock is estimated at 3-4 kg/rai, which is well below the national average of 15 kg/rai. Fishing is mainly practised for own consumption

17 Development of capture fisheries must aim at *(1) preservation of biodiversity and habitats (including water quality, important migration routes and breeding grounds), and (2) prevention of over-exploitation.* The potential for commercial development is small, but the possibility exists of increasing the yield from capture fisheries in (present and future) reservoirs. A particular concern is the risk of contamination of edible fishes by pesticides from agriculture

18 There are eight planned reservoirs in Fang, Upper Lao and Suai sub-basins. They will control some 20 percent of the Fang sub-basin, some 26 percent of Upper Lao sub-basin, and nearly all of the Suai sub-basin. In total, they will generate a potential irrigable area of 205,000 rai. This is an expansion by 30 percent of the area that is potentially irrigable today. The effective impact is larger, because the scarcity of water implies that not all the potential irrigable area can actually be irrigated, particularly in the dry season. It is expected that the actually irrigated areas will increase by 55 percent and 33 percent in the dry and the wet season, respectively. The Nawang Reservoir has the important side objective to serve the domestic demand in Fang District. In general, the planned developments are found hydrologically feasible

19 There is a need of rehabilitation or upgrading of some of the existing schemes, in order to improve their water efficiency. There is also scope for non-structural development measures, like improvement of irrigation management and field application efficiencies. It is evaluated that such measures can improve the water efficiency from 30 percent today to 40 percent in the future. This makes it possible to increase the irrigable area by 10 and 7 percent in the wet and the dry season, respectively. This improvement can be achieved at little or no environmental cost

20 Separate goals must be pursued for upland agro-forestry cultivation. Forest ecosystems are fragile and under pressure. Agro-forestry is an option for sustaining the upland and mountainous ecosystems, while, at the same time, stabilising the living conditions of the farmers.

Management options comprise (i) stabilisation of sloping areas; (ii) maintenance and improvement of the soil fertility; and (iii) improvement of the microclimate. In the medium term, in order to prevent stagnation and marginalisation, additional sources of income must be sought as a supplement to subsistence cultivation

21 The tourism sector appears as an attractive option for economic development in the medium term, and, in case of prudent management, in the long term as well. The development should aim at *higher earnings per day spent by tourists, minimising the environmental and social impact, and maximising the socio-economic benefit.*

Priority concerns

22 Reforestation

23 Abatement of soil erosion (including non-structural measures)

24 Formulation of transparent and long-term land use policies, building on clearly delineated zones for agriculture, high-density housing, industry, different categories of forests, wetlands, natural heritage areas, cultural heritage sites, etc. Implementation should be gradual, as a precondition for acceptance by stakeholders, and should among other aims provide measures against excessive, unplanned urbanisation

25 Preservation of a groundwater quality that meets with drinking water standard

26 Preservation of a surface water quality that meets with standards that have been agreed among the stakeholders

27 Satisfaction of the ecological demand of surface water

28 Preservation of a biodiversity in forests and surface waters (including wetlands) that complies with goals that have been agreed among the stakeholders

29 Promotion of agricultural practices with high water efficiencies and high value of production per unit of water

30 Preservation of sustainable practices: (1) Traditional upland cultivation practices; (2) community forests; and (3) small-scale capture fisheries

31 Sustainable development of the tourism sector, including promotion of (1) eco-tourism; and (2) of measures to increase the earnings generated per visitor-day

Practicalities

32 Physical regulation of water resources, including implementation of new irrigation schemes and rehabilitation of existing ones, should proceed in due course

33 A water fee is not high on today's political agenda, but some sort of economic incentive will eventually be necessary for demand regulation and improvement of water efficiencies

34 Distribution losses should be reduced wherever possible, both in (1) urban distribution networks, and (2) in irrigation systems

35 Groundwater abstraction should be comprehensively regulated before scarcity and conflicts of interests emerge. Groundwater should be regarded as a public asset that requires some sort of permit for utilisation The first right to groundwater (if available) should be given to the most important uses. Urban supplies, rural domestic supplies, and activities with a high earning per unit of water

36 Good agricultural practices should be encouraged. A good general understanding should be built about the environmental risks related to soil deterioration and use of pesticides

37 Monitoring should be made of heavy metals in fertilisers, and a policy should be formulated on prudent use of fertilisers and pesticides (types and practices)

38 Documentation, regulation and monitoring of land use should be implemented

39 Provision of a close and functional coordination between involved line agencies

40 Regarding the ecological demand of surface water, more knowledge is required. A pilot project should be initiated to assess this demand, and its distribution in time and space

41 Maintenance of a suitable regulation of small-scale capture fisheries

Figure 6.1: The Kok-Mekong confluence

6.5 Public awareness and public participation

Reference and basis

Eighth Economic and Social Development Plan (Part VI, Chapters 1 and 3, cf. Appendix C)

Institutional arrangements for the administration and management of natural resources and environment of watersheds in Thailand (November 1996)

MRCS Guidelines (April 1999)

SR-13

Issues, options and constraints

1 Public participation can build public awareness and orientation towards the agreed goals, and this can be one of the most important forces during implementation

2 The process should proceed through the public representative institutions (the provincial governments and the tambons). The active involvement of these institutions is a mutual advantage that can strengthen the institutions and the planning process at the same time

3 The participation can be direct and/or indirect. In many cases, NGOs are in a particular position to supply knowledge and experience about concerns, priorities and constraints that can affect implementation of the plan

4 Beforehand, it is evaluated that a positive attitude can be relied on towards integrated management of water resources and the environment

Priority concerns

5 Broad public awareness towards preservation of natural resources and the environment, including knowledge about governing cause-effect relationships

6 Broad public support to management and regulation

7 Authority to be de-centralised as far as functional, subject to (1) the need of national coordination and harmonisation between sectors; and (2) institutional capacity requirements (in terms of experience and professional skills)

8 Orientation of public authorities (line agencies and provincial administration) towards dialogue with the stakeholders, and related institutional capacity-building

Practicalities

9 Confidence should build on a mutual understanding that (i) stakeholder interests can be inconsistent; (ii) that it may for that reason happen that not all interests can be accommodated; and (iii) that a demand of full consensus can lead to stagnation

10 It should be made clear beforehand whether a public hearing aims at an exchange of information, or whether it aims at a partial endorsement. This is in order to avoid a frustration that can be counter-productive. Both objectives can be important, but participants may be disappointed if they expect information and are asked for an endorsement instead, or the other way round

11 Public participation should build on and involve the formal structure of political representation, notably the provincial governments and the new tambon administrations. This is in order to achieve a fruitful interaction, where the institutions are strengthened by their active participation, while they can in turn support knowledge and authority that is important for the planning process

12 Public participation should comprise an active dialogue with relevant NGOs and the press. The NGOs represent a substantial expertise, and a practical insight and experience that can contribute effectively to the planning process. The press serves as a communication channel that can relay information among different stakeholders, and between the stakeholders and the policy makers

13 A good general understanding should be built about the particular environmental risks related to soil deterioration and use of pesticides, because these risks cannot easily be managed by formal regulation

14 Attention must be paid to issues and concerns raised by the general public or by NGOs, for several reasons, including the desire to sustain a trustworthy general dialogue about environmental preservation. Obviously, not all ideas and suggestions can be implemented, but stakeholders and the general public must be assured that concerns and issues raised are actually apprehended and considered, although perhaps in a wider context. As a minimum, however, feedback must be given, and knowledge shared

Bibliography

General

Thailand's action for sustainable development. Country report to UN Commission on Sustainable Development, Ministry of Science, Technology and Environment, Thailand, March 1997

Mekong River Commission, Annual Report, 1997

Chao Phraya Basin water management strategy. National Economic and Social Development Board, Royal Irrigation Department, Pollution Control Department, October 1997

Chao Phraya flood management review. World Bank, November 1996

Improved land and water use in Northern Thailand. Report on proposed activities for follow-up phase, Mekong River Commission

Improved land and water use in Northern Thailand. Final Report, Mekong River Commission

Improved land and water use in Northern Thailand. Water resource management status report, Department of Agricultural Extension, Mekong River Commission, and Danish International Development Assistance, October 1995

Agreement on the cooperation for the sustainable development of the Mekong River Basin. Mekong River Commission, April 1995

Environmental and ecological impact assessment of Kok Project, Electricity Generating Authority of Thailand, January 1985

Mae Kok Project, Fang Basin. Prefeasibility report, Department of Energy Planning and Promotion and Royal Irrigation Department, 1973

Integrated planning

Nguyen Duc Lien: Mekong development, achievements and future plan. Seminar on Large River Ecosystem Management, Hanoi, 12-24 February 1993, Mekong Secretariat, February 1993

Consultancy services for integrated land and water use for sustainable agricultural development in The Lower Mekong Basin. Final Report submitted to Mekong River Commission Secretriat by Danagro Advisers A/S, July 1996. Annexes include Country Perspective Papers for each MRC member country

Douglas Webster: Establishing a strategic planning process in the Mekong River Commission: Some notes on methodology. Prepared for the Mekong River Commission, December, 1996

Claudia Ringler: Optimal allocation and use of water resources in the Mekong River Basin: An intersectoral focus (in preparation, June 2000)

Henrik Larsen (ed).: Integrated water resources management. TAC Background Papers no. 4, published by the Technical Advisory Committee of the Global Water Partnership, March 2000

Government of Thailand: The Eighth National Economic and Social Development Plan (1997-2001). National Economic and Social Development Board, Office of the Prime Minister, Bangkok. Available on the Internet in Thai and English (www.nesdb.go.th)

Water resources

MIKE Basin User manual, Danish Hydraulic Institute, January 1999

Study on the Kok-Ing-Nan water diversion project. Conceptual planning study. Royal Irrigation Department and Japanese International Cooperation Agency, 1997

Study of potential development of water resources in the Mae Khong River Basin, Office of the National Economic and Social Development Board, May 1994

NAM - MIKE 11 Documentation and users guide, Danish Hydraulic Institute, August 1990

Peter Rogers, Ramesh Bhatia and Annette Huber: Water as a social and economic good: How to put the principles into practice. TAC Background Papers no. 2, published by the Technical Advisory Committee of the Global Water Partnership, August 1998

Agriculture and Irrigation Programme for Co-operation Towards Sustainable Development of the Lower Mekong Basin. Mekong River Commission Secretariat, November 1998; incl. (among others) Annex 2: Impact of irrigation projects on the fisheries sector; and Annex 4: Agricultural strategies and policies in the member countries

Formulation of hydropower development strategy for the Mekong River Commission, endorsed by the Joint Committee at its Eighth meeting, 8-9 September 1998, Phnom Penh

Environment, water pollution

Policy and prospective plan for enhancement and conservation of national environmental quality 1997-2016. Office of Environmental Policy and Planning, Ministry of Science, technology and Environment, Thailand, December 1997

Stephen F. Matthews and Sunee Mallikamarl: Environmental protection and pollution control in Thailand: Western Standards, Thai Ways. Presented at the UK-USA Agricultural and Environmental Law Symposium at Oxford University on September 19, l995

LOAD - Users guide, Danish Water Quality Institute, September 1998

A GIS assessment of non-point source pollution in the San Antonio-Nueces coastal basin. Centre for Research in Water Resources, University of Texas, August 1996

Pollution Thailand 1995. Pollution Control Department, June 1996

Greater Mekong Sub-region, state-of-the-environment report. United Nations Environment Programme and Mekong River Commission, June 1997

Estimating non-point source pollution loads with a GIS screening model. Water Resources Bulletin, August 1995

WHO training course on coastal pollution control, Vol III. Danish International Development Assistance, 1978

Watershed management

Mekong watershed classification, WSC map users guide, Mekong River Commission Secretariat

GIS applications for watershed classification. WSC data users guide, Mekong River Commission Secretariat

Bertold Schrempp: Concept paper for the preparation of a watershed management/forestry sector strategy for the Mekong Secretariat. January 1995

The Mighty Mekong Mystery - a study on the problems and possibilities of natural resources utilisation in the Mekong River Basin. Prepared for SIDA by Area Forecasting Institute, February 1997

Public participation

Institutional arrangements for the administration and management of natural resources and environment of watersheds in Thailand, November 1996

Towards public participation in Mekong River Basin development. Integrated Report submitted to The Mekong River Commission Secretariat by Natural Resources and Environment Program, Thailand Development Research Institute, September 1998

Kobkun Rayanakorn, Mingsarn Kaosaard, Craig Johnson, Pinida Kongsiri and Arnel B. Rala: Thailand country paper, submitted to The Mekong River Commission Secretariat by Natural Resources and Environment Program, Thailand Development Research Institute, April 1998

Public participation in the context of the MRC. Prepared by the Mekong River Commission Secretariat, April 1999

Guidelines on mainstreaming gender in water resources development in the Lower Mekong Basin. Prepared by Alexandra Stephens for The Mekong River Commission Secretariat, August 1998

Appendix A
Sub-basin summaries of water balance and demand

Explanations

Provinces and districts are indicated if a part of them is within the sub-basin

April has been selected as an illustrative month for water availability, as it is critical in terms of streamflow and (expectedly) in terms of ecological demand. The month with the lowest rainfall is January. The month with the lowest (present, actual) satisfaction of irrigation demand is July (where water is required for land preparation for the main rice crop, which will be harvested in October). (For this reason, the present, actual irrigation demand is higher in the wet season than in the dry season in several of the sub-basins)

Actual evaporation and surface runoff have been calculated by the NAM model. The surface runoff is the surface water resources generated in the sub-basin

Flow from upstream, present withdrawals and corresponding return flows are outputs of the MIKE BASIN model. On a long-term average basis, the flow from upstream into a sub-basin (for example Lower Kok) will equal the 'flow to downstream' from the upstream catchments (in this example, Upper Kok and Lower Lao). Under 'reliable flow' conditions, however, there may be a small difference, because 'reliable flow' does not occur at the same time in every sub-basin

The *groundwater recharge* is generally small, because today, groundwater is not widely used. Values are sometimes negative, because the summaries describe situations that are drier than average

Ecological demand (in April) is estimated as 1 l/s per km2 of catchment area

The *'area suited for cultivation'* is the area that is suited or moderately suited for paddy cultivation, considering the surface slope and soil properties. The area is determined as class P1, P2 and P3 of the soil suitability classification system applied by Land Development Department

The *demand* (of irrigation water) is the irrigation requirement for two crops grown on the entire irrigation project area (assuming that water was amply available). The *withdrawal* at a given crop intensity is the serviceable irrigation requirement, as limited by the actual water availability, in case of actual cultivation practices (which in turn reflect the general water availability). The tables show average values, assuming paddy as representative crop in the wet season, and cash crops (illustrated by shallot) in the dry season. The irrigation requirement has been estimated as the crop requirement divided by 30 percent

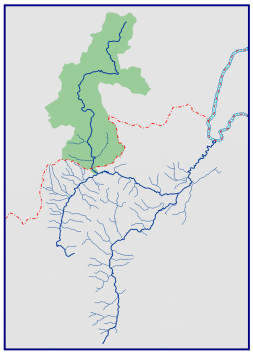
The *demand satisfaction* is the actual availability in percent of the irrigation requirement. Values listed are the lowest demand satisfaction in a season over a time scale of at least one week (assuming that a water scarcity is not critical to the cultivation if it lasts for a few days only)

The *domestic demand* is estimated at 312 l/person/day for Chiang Rai Municipality, and 200 l/person/day elsewhere

Myanmar (without Nam Kok)

Sub-basin summary of water balance and demands

Main river length: 180 km
Area: 3,363 km² (32 percent of Kok River Basin)



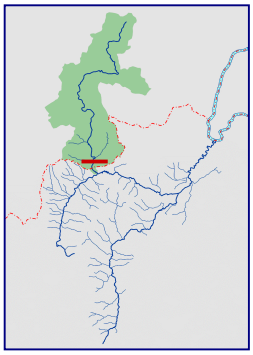
		Annual 'reliable' (4 of 5 years)	April 'reliable' (4 of 5 years)	Notes
Rainfall	a	1,414.5 mm	48.9 mm	
Actual evaporation	b	880.1 mm	40.1 mm	
Net rainfall	a - b	534.4 mm	8.8 mm	
Surface runoff	c	552.3 mm	11.9 mm	
Surface runoff	c	58.9 m3/s	15.4 m3/s	
Groundwater recharge	a - b - c	-1.9 m3/s	-4.0 m3/s	
Flow from upstream	d	-	-	
Surface water resource	c + d	58.9 m3/s	15.4 m3/s	
Ecological demand	e	3.4 m3/s	3.4 m3/s	
Available to supplies	c + d - e	55.5 m3/s	12.0 m3/s	

Present withdrawals	f	-	-	
Corresponding return flows	g	-	-	
Flow to downstream	c + d - f + g	58.9 m3/s	15.4 m3/s	

Myanmar (including Nam Kok)

Sub-basin summary of water balance and demands

Main river length: 180 km
Area: 3,363 km² (32 percent of Kok River Basin)

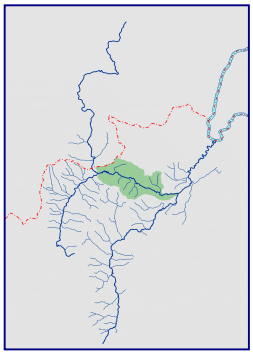


		Annual 'reliable' (4 of 5 years)	April 'reliable' (4 of 5 years)	Notes
Rainfall	a	1,414.5 mm	48.9 mm	
Actual evaporation	b	880.1 mm	40.1 mm	
Net rainfall	a - b	534.4 mm	8.8 mm	
Surface runoff	c	552.3 mm	11.9 mm	
Surface runoff	c	58.9 m3/s	15.4 m3/s	
Groundwater recharge	a - b - c	-1.9 m3/s	-4.0 m3/s	
Flow from upstream	d	-	-	
Surface water resource	c + d	58.9 m3/s	15.4 m3/s	
Ecological demand	e	3.4 m3/s	3.4 m3/s	
Available to supplies	c + d - e	55.5 m3/s	12.0 m3/s	
Present withdrawals	f	-	-	
Corresponding return flows	g	4.0 m3/s	47.5 m3/s	1)
Flow to downstream	c + d - f + g	62.9 m3/s	62.9 m3/s	

1) This is the estimated net release under 'reliable flow' conditions

Upper Kok (without Nam Kok)

Sub-basin summary of water balance and demands



Main river length: 62 km
Area: 931 km² (9 percent of Kok River Basin)
Provinces (districts):
Chiang Rai (Muang Chiang Rai,
Mae Fa Luang, Mae Suai);
Chiang Mai (Mae Ai)

		Annual 'reliable' (4 of 5 years)	April 'reliable' (4 of 5 years)	Notes
Rainfall	a	1,470.8 mm	51.4 mm	
Actual evaporation	b	845.5 mm	57.4 mm	
Net rainfall	a - b	625.3 mm	-6.0 mm	
Surface runoff	c	656.1 mm	2.8 mm	
Surface runoff	c	19.4 m3/s	1.0 m3/s	
Groundwater recharge	a - b - c	-0.9 m3/s	-3.2 m3/s	
Flow from upstream	d	87.2 m3/s	16.6 m3/s	
Surface water resource	c + d	106.6 m3/s	17.6 m3/s	
Ecological demand	e	6.2 m3/s	6.2 m3/s	
Available to supplies	c + d - e	100.4 m3/s	11.4 m3/s	

Present withdrawals	f	4.4 m3/s	4.2 m3/s	
Corresponding return flows	g	1.3 m3/s	1.3 m3/s	
Flow to downstream	c + d - f + g	103.5 m3/s	14.7 m3/s	

	km2	Percent of sub-basin area	
Area suited for cultivation	84	9	
Present irrigation project area	53	6	
Future irrigation project area (present + planned)	53	6	

Present irrigation project area	**Wet season, 6-months average**	**Dry season, 6-months average**	
Demand at 200 percent crop intensity	1.4 m3/s	2.5 m3/s	
Withdrawal at 110 percent crop intensity	1.4 m3/s	0.3 m3/s	1)
Return flow	30 percent	30 percent	

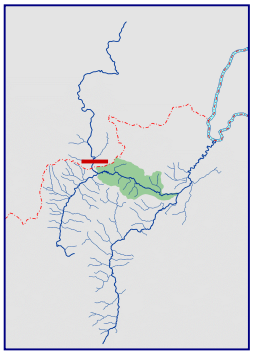
Future irrigation project area (present + planned)			
Demand at 200 percent crop intensity	1.4 m3/s	2.5 m3/s	
Withdrawal at 110 percent crop intensity	1.4 m3/s	0.3 m3/s	2)
Return flow	30 percent	30 percent	

	1997	2020	
Population	130,781	766,325	
Part of population living in Chiang Rai Municipality	26 percent	84 percent	
Domestic demand	0.3 m3/s	2.6 m3/s	
Return flow	80 percent	80 percent	

1): Demand satisfaction is 100 percent
2): Demand satisfaction is 95 percent in the wet season and 100 percent in the dry season

Upper Kok (including Nam Kok)

Sub-basin summary of water balance and demands



Main river length: 62 km
Area: 931 km² (9 percent of Kok River Basin)
Provinces (districts):
Chiang Rai (Muang Chiang Rai,
Mae Fa Luang, Mae Suai);
Chiang Mai (Mae Ai)

		Annual 'reliable' (4 of 5 years)	April 'reliable' (4 of 5 years)	Notes
Rainfall	a	1,470.8 mm	51.4 mm	
Actual evaporation	b	845.5 mm	57.4 mm	
Net rainfall	a - b	625.3 mm	-6.0 mm	
Surface runoff	c	656.1 mm	2.8 mm	
Surface runoff	c	19.4 m3/s	1.0 m3/s	
Groundwater recharge	a - b - c	-0.9 m3/s	-3.2 m3/s	
Flow from upstream	d	87.2 m3/s	66.7 m3/s	
Surface water resource	c + d	109.2 m3/s	67.7 m3/s	
Ecological demand	e	6.2 m3/s	6.2 m3/s	
Available to supplies	c + d - e	103.0 m3/s	61.5 m3/s	
Present withdrawals	f	4.5 m3/s	4.2 m3/s	
Corresponding return flows	g	1.3 m3/s	1.3 m3/s	
Flow to downstream	c + d - f + g	106.0 m3/s	64.8 m3/s	

	km2	Percent of sub-basin area	
Area suited for cultivation	84	9	
Present irrigation project area	53	6	
Future irrigation project area (present + planned)	53	6	

Present irrigation project area	**Wet season, 6-months average**	**Dry season, 6-months average**	
Demand at 200 percent crop intensity	1.4 m3/s	2.5 m3/s	
Withdrawal at 110 percent crop intensity	1.4 m3/s	0.3 m3/s	1)
Return flow	30 percent	30 percent	

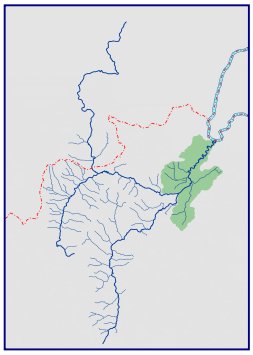
Future irrigation project area (present + planned)			
Demand at 200 percent crop intensity	1.4 m3/s	2.5 m3/s	
Withdrawal at 110 percent crop intensity	1.4 m3/s	0.3 m3/s	2)
Return flow	30 percent	30 percent	

	1997	2020	
Population	130,781	766,325	
Part of population living in Chiang Rai Municipality	26 percent	84 percent	
Domestic demand	0.3 m3/s	2.6 m3/s	
Return flow	80 percent	80 percent	

1): Demand satisfaction is 100 percent
2): Demand satisfaction is 95 percent in the wet season and 100 percent in the dry season

Lower Kok (without Nam Kok)

Sub-basin summary of water balance and demands



Main river length: 84 km
Area: 1,205 km² (11 percent of Kok River Basin)
Province (districts):
Chiang Rai (Muang Chiang Rai,
Doi Luang, Wiang Chieng Rung, Wiang Chai,
Mae Chan, Chiang Saen)

		Annual 'reliable' (4 of 5 years)	April 'reliable' (4 of 5 years)	Notes
Rainfall	a	1,428.6 mm	46.8 mm	
Actual evaporation	b	939.2 mm	45.8 mm	
Net rainfall	a - b	489.4 mm	1.0 mm	
Surface runoff	c	541.5 mm	2.5 mm	
Surface runoff	c	20.7 m3/s	1.2 m3/s	
Groundwater recharge	a - b - c	-2.0 m3/s	-0.7 m3/s	
Flow from upstream	d	119.3 m3/s	16.3 m3/s	
Surface water resource	c + d	140.0 m3/s	17.5 m3/s	
Ecological demand	e	10.6 m3/s	10.6 m3/s	
Available to supplies	c + d - e	129.4 m3/s	6.9 m3/s	
Present withdrawals	f	50.4 m3/s	0.8 m3/s	
Corresponding return flows	g	0.6 m3/s	0.2 m3/s	
Flow to downstream	c + d - f + g	90.2 m3/s	16.9 m3/s	

	km2	Percent of sub-basin area	
Area suited for cultivation	514	43	
Present irrigation project area	256	21	
Future irrigation project area (present + planned)	256	21	

Present irrigation project area	Wet season, 6-months average	Dry season, 6-months average	
Demand at 200 percent crop intensity	6.8 m3/s	12.2 m3/s	
Withdrawal at 110 percent crop intensity	6.2 m3/s	1.3 m3/s	1)
Return flow	30 percent	30 percent	

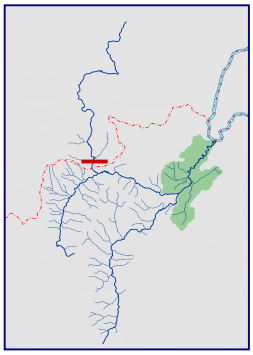
Future irrigation project area (present + planned)			
Demand at 200 percent crop intensity	6.8 m3/s	12.2 m3/s	
Withdrawal at 110 percent crop intensity	5.8 m3/s	1.3 m3/s	2)
Return flow	30 percent	30 percent	

	1997	2020	
Population	153,202	330,351	
Part of population living in Chiang Rai Municipality	6 percent	52 percent	
Domestic demand	0.4 m3/s	1.0 m3/s	
Return flow	80 percent	80 percent	

1): Demand satisfaction is 100 percent
2): Demand satisfaction is 95 percent in the wet season and 100 percent in the dry season

Lower Kok (including Nam Kok)

Sub-basin summary of water balance and demands



Main river length: 84 km
Area: 1,205 km² (11 percent of Kok River Basin)
Province (districts):
Chiang Rai (Muang Chiang Rai,
Doi Luang, Wiang Chieng Rung, Wiang Chai,
Mae Chan, Chiang Saen)

		Annual 'reliable' (4 of 5 years)	April 'reliable' (4 of 5 years)	Notes
Rainfall	a	1,428.6 mm	46.8 mm	
Actual evaporation	b	939.2 mm	45.8 mm	
Net rainfall	a - b	489.4 mm	1.0 mm	
Surface runoff	c	541.5 mm	2.5 mm	
Surface runoff	c	20.7 m3/s	1.2 m3/s	
Groundwater recharge	a - b - c	-2.0 m3/s	-0.7 m3/s	
Flow from upstream	d	123.1 m3/s	67.9 m3/s	
Surface water resource	c + d	143.8 m3/s	69.1 m3/s	
Ecological demand	e	10.6 m3/s	10.6 m3/s	
Available to supplies	c + d - e	133.2 m3/s	58.5 m3/s	

Present withdrawals	f	50.4 m3/s	0.8 m3/s	
Corresponding return flows	g	0.7 m3/s	0.2 m3/s	
Flow to downstream	c + d - f + g	94.1 m3/s	68.5 m3/s	

	km2	Percent of sub-basin area	
Area suited for cultivation	514	43	
Present irrigation project area	256	21	
Future irrigation project area (present + planned)	256	21	

Present irrigation project area	**Wet season, 6-months average**	**Dry season, 6-months average**	
Demand at 200 percent crop intensity	6.8 m3/s	12.2 m3/s	
Withdrawal at 110 percent crop intensity	6.2 m3/s	1.3 m3/s	1)
Return flow	30 percent	30 percent	

Future irrigation project area (present + planned)			
Demand at 200 percent crop intensity	6.8 m3/s	12.2 m3/s	
Withdrawal at 110 percent crop intensity	5.8 m3/s	1.3 m3/s	2)
Return flow	30 percent	30 percent	

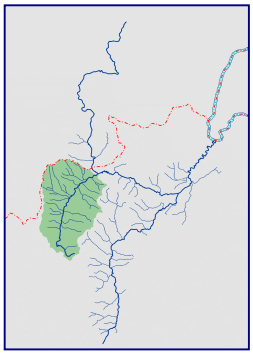
	1997	2020	
Population	153,202	330,351	
Part of population living in Chiang Rai Municipality	6 percent	52 percent	
Domestic demand	0.4 m3/s	1.0 m3/s	
Return flow	80 percent	80 percent	

1): Demand satisfaction is 100 percent
2): Demand satisfaction is 95 percent in the wet season and 100 percent in the dry season

Fang

Sub-basin summary of water balance and demands

Main river length: 117 km
Area: 1,920 km² (18 percent of Kok River Basin)
Province (districts):
Chiang Mai (Chai Prakarn, Fang, Mae Ai, Phrao)



		Annual 'reliable' (4 of 5 years)	April 'reliable' (4 of 5 years)	Notes
Rainfall	a	1,132.8 mm	28.9 mm	
Actual evaporation	b	692.0 mm	24.2 mm	
Net rainfall	a - b	440.8 mm	4.7 mm	
Surface runoff	c	478.7 mm	3.6 mm	
Surface runoff	c	29.1 m3/s	2.7 m3/s	
Groundwater recharge	a - b - c	-2.3 m3/s	0.8 m3/s	
Flow from upstream	d	-	-	
Surface water resource	c + d	29.1 m3/s	2.7 m3/s	
Ecological demand	e	1.9 m3/s	1.9 m3/s	
Available to supplies	c + d - e	27.2 m3/s	0.8 m3/s	

Present withdrawals	f	6.4 m3/s	3.9 m3/s	
Corresponding return flows	g	2.0 m3/s	1.2 m3/s	
Flow to downstream	c + d - f + g	24.7 m3/s	-0.0 m3/s	

	km2	Percent of sub-basin area	
Area suited for cultivation	211	11	
Present irrigation project area	272	14	
Future irrigation project area (present + planned)	367	19	

Present irrigation project area	**Wet season, 6-months average**	**Dry season, 6-months average**	
Demand at 200 percent crop intensity	10.9 m3/s	13.7 m3/s	
Withdrawal at 130 percent crop intensity	7.5 m3/s	3.3 m3/s	1)
Return flow	30 percent	30 percent	

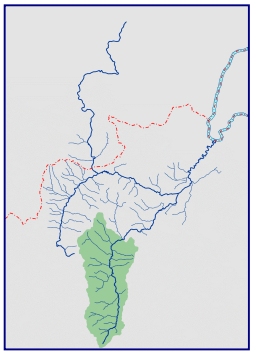
Future irrigation project area (present + planned)			
Demand at 200 percent crop intensity	14.7 m3/s	18.5 m3/s	
Withdrawal at 130 percent crop intensity	10.9 m3/s	5.1 m3/s	2)
Return flow	30 percent	30 percent	

	1997	2020	
Population	188,419	205,824	
Domestic demand	0.4 m3/s	0.5 m3/s	
Return flow	80 percent	80 percent	

1): Demand satisfaction is 70 percent in the wet season and 65 percent in the dry season
2): Demand satisfaction is 80 percent

Upper Lao

Sub-basin summary of water balance and demands



Main river length: 111 km
Area: 2,091 km² (20 percent of Kok River Basin)
Provinces (districts):
Chiang Rai (Mae Suai, Wiang Pa Pao);
Chiang Mai (Chai Prakarn, Fang, Mae Ai, Phrao)

		Annual 'reliable' (4 of 5 years)	April 'reliable' (4 of 5 years)	Notes
Rainfall	a	929.7 mm	28.9 mm	
Actual evaporation	b	727.1 mm	24.2 mm	
Net rainfall	a - b	202.6 mm	4.7 mm	
Surface runoff	c	204.1 mm	3.6 mm	
Surface runoff	c	13.5 m3/s	2.9 m3/s	
Groundwater recharge	a - b - c	-0.1 m3/s	0.9 m3/s	
Flow from upstream	d	-	-	
Surface water resource	c + d	13.5 m3/s	2.9 m3/s	
Ecological demand	e	2.1 m3/s	2.1 m3/s	
Available to supplies	c + d - e	11.4 m3/s	0.8 m3/s	

Present withdrawals	f	4.6 m3/s	12 m3/s	
Corresponding return flows	g	1.4 m3/s	0.4 m3/s	
Flow to downstream	c + d - f + g	10.3 m3/s	2.1 m3/s	

	km2	Percent of sub-basin area	
Area suited for cultivation	105	5	
Present irrigation project area	108	5	
Future irrigation project area (present + planned)	316	15	

Present irrigation project area	**Wet season, 6-months average**	**Dry season, 6-months average**	
Demand at 200 percent crop intensity	5.7 m3/s	15.6 m3/s	
Withdrawal at 112 percent crop intensity	3.8 m3/s	1.1 m3/s	1)
Return flow	30 percent	30 percent	

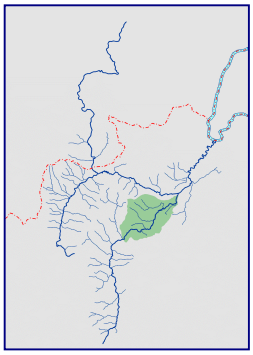
Future irrigation project area (present + planned)			
Demand at 200 percent crop intensity	16.6 m3/s	16.3 m3/s	
Withdrawal at 120 percent crop intensity	10.0 m3/s	3.0 m3/s	2)
Return flow	30 percent	30 percent	

	1997	2020	
Population	120,097	138,772	
Domestic demand	0.3 m3/s	0.3 m3/s	
Return flow	80 percent	80 percent	

1): Demand satisfaction is 55 percent in the wet season and 85 percent in the dry season
2): Demand satisfaction is 65 percent in the wet season and 80 percent in the dry season

Lower Lao

Sub-basin summary of water balance and demands



Main river length: 80 km
Area: 618 km² (6 percent of Kok River Basin)
Province (districts):
Chiang Rai (Muang Chiang Rai,
Phan, Mae Suai, Wiang Chai, Mae Lao)

		Annual 'reliable' (4 of 5 years)	April 'reliable' (4 of 5 years)	Notes
Rainfall	a	1,271.2 mm	49.9 mm	
Actual evaporation	b	825.2 mm	77.8 mm	
Net rainfall	a - b	446.0 mm	-27.9 mm	
Surface runoff	c	485.3 mm	6.0 mm	
Surface runoff	c	9.5 m3/s	1.4 m3/s	
Groundwater recharge	a - b - c	-0.8 m3/s	-8.1 m3/s	
Flow from upstream	d	11.9 m3/s	3.1 m3/s	
Surface water resource	c + d	21.4 m3/s	4.5 m3/s	
Ecological demand	e	3.1 m3/s	3.1 m3/s	
Available to supplies	c + d - e	18.3 m3/s	1.4 m3/s	
Present withdrawals	f	4.0 m3/s	3.9 m3/s	
Corresponding return flows	g	1.2 m3/s	1.2 m3/s	
Flow to downstream	c + d - f + g	18.6 m3/s	1.8 m3/s	

	km2	Percent of sub-basin area	
Area suited for cultivation	279	45	
Present irrigation project area	391	63	
Future irrigation project area (present + planned)	391	63	

Present irrigation project area	**Wet season, 6-months average**	**Dry season, 6-months average**	
Demand at 200 percent crop intensity	13.7 m3/s	19.3 m3/s	
Withdrawal at 112 percent crop intensity	6.8 m3/s	1.9 m3/s	1)
Return flow	30 percent	30 percent	

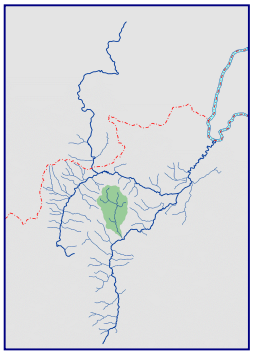
Future irrigation project area (present + planned)			
Demand at 200 percent crop intensity	13.7 m3/s	19.3 m3/s	
Withdrawal at 120 percent crop intensity	9.7 m3/s	2.1 m3/s	2)
Return flow	30 percent	30 percent	

	1997	2020	
Population	83,306	201,194	
Part of population living in Chiang Rai Municipality	7 percent	57 percent	
Domestic demand	0.2 m3/s	0.6 m3/s	
Return flow	80 percent	80 percent	

1): Demand satisfaction is 55 percent in the wet season and 85 percent in the dry season
2): Demand satisfaction is 70 percent in the wet season and 100 percent in the dry season

Suai

Sub-basin summary of water balance and demands



Main river length: 50 km
Area: 437 km² (4 percent of Kok River Basin)
Provinces (districts):
Chiang Rai (Mae Suai);
Chiang Mai (Mae Ai)

		Annual 'reliable' (4 of 5 years)	April 'reliable' (4 of 5 years)	Notes
Rainfall	a	1,278.8 mm	39.9 mm	
Actual evaporation	b	820.6 mm	67.5 mm	
Net rainfall	a - b	458.2 mm	-27.6 mm	
Surface runoff	c	489.0 mm	5.7 mm	
Surface runoff	c	6.8 m3/s	1.0 m3/s	
Groundwater recharge	a - b - c	-0.4 m3/s	-5.6 m3/s	
Flow from upstream	d	-	-	
Surface water resource	c + d	6.8 m3/s	1.0 m3/s	
Ecological demand	e	0.4 m3/s	0.4 m3/s	
Available to supplies	c + d - e	6.4 m3/s	0.6 m3/s	

Present withdrawals	f	-	-	
Corresponding return flows	g	-	-	
Flow to downstream	c + d - f + g	6.8 m3/s	1.0 m3/s	

	km2	Percent of sub-basin area	
Area suited for cultivation	-	-	
Present irrigation project area	-	-	
Future irrigation project area (present + planned)	11	2.5	

Present irrigation project area	**Wet season, 6-months average**	**Dry season, 6-months average**	
Demand at 200 percent crop intensity	- m3/s	- m3/s	
Withdrawal	- m3/s	- m3/s	1)
Return flow	30 percent	30 percent	

Future irrigation project area (present + planned)			
Demand at 200 percent crop intensity	0.4 m3/s	0.5 m3/s	
Withdrawal	- m3/s	- m3/s	1)
Return flow	30 percent	30 percent	

	1997	2020	
Population	25211	31718	
Domestic demand	0.1 m3/s	0.1 m3/s	
Return flow	80 percent	80 percent	

1): Present and future withdrawals are insignificant

Appendix B
Resumes of thematic studies and sector studies

This appendix presents ultra-short summaries of the Special Reports that have been produced in connection with the project.

SR-1 Water resources

The water resources study is a cornerstone of the entire project. Its objective is to produce an insight into present and future water availability and water demand. The study builds partly on the rainfall-runoff modelling study (SR-2) and the water resources modelling study (SR-3)..

The study lists the available hydrological data: Rainfall (22 stations, 22 years, data coverage 92 percent), streamflow (10 stations, up to 20 years), and climatological data (1 station, 30 years). On this basis, annual water balances are presented. Information about groundwater is minimal.

Present and planned irrigation schemes are described. Today, an area of 675,460 rai is irrigated by 227 schemes. Planned projects (excluding the Nam Kok scheme in Myanmar) will generate a potential irrigable area of 196,000 rai. This represents an expansion of 29 percent. The actual effect is larger, because the scarcity of water implies that not all the potentially irrigable area can actually be irrigated, particularly in the dry season. It is found that the actually irrigated areas will increase by 55 percent and 33 percent in the dry and the wet season, respectively (or 130,000 rai and 638,000 rai). The regulation will also reduce the flood risk in the wet season. The average flow (for the entire basin) is expected to decrease by 30 percent.

The demand of water is analysed in depth for irrigation, which is by far the predominant use. The analysis comprises crop water requirements, effective rainfall, and irrigation efficiencies. A representative cropping calendar for water demand is composed of paddy in the wet season (June through October) and shallot in the dry season (January through April).

The findings of the study are summarised in concluding chapters that evaluate the planned developments and the development potential as such. In general, the planned developments are found useful and technically and hydrologically feasible. Demand side management will be less effective, but will also require less investments and have much less environmental and social effects. Watershed management can improve the natural storage, and rehabilitation of irrigation schemes can improve their efficiency. There is also scope for non-structural development measures, like improvement of irrigation management and field application efficiencies.

SR-2 Rainfall-runoff modelling

This activity has comprised (i) analysis of rainfall and streamflow data; and (ii) hydrological modelling of the water balance of the basin.

Following a data review, 13 rainfall stations were applied, with an average data coverage of 90 percent. All the stations are located in the Thai part of the Basin. The rainfall in the Myanmar part has been estimated from Thai stations near the border.

The modelling was made by the NAM model, which is a conceptual distributed rainfall-runoff model. The model describes exchanges between (1) the atmosphere; (2) a snow cover (if any); (3) surface storage; (3) root zone storage; and (5) the groundwater. Among the transport mechanisms are rainfall, evaporation, evapotranspiration, overland flow, infiltration, capillary flux, groundwater flow and abstraction.

For the purpose of the analysis, the Basin was divided into 7 sub-basins. The model was calibrated against measured discharges covering 74 percent of the total area. The time increment was 1 day.

The analysis comprised the period 1976-1997 (22 years). Over this period, the water balance of the Basin changed visibly. In 1976-86, the surface runoff was 34 percent of the rainfall, while in 1987-97, the surface runoff had increased to 46 percent of the rainfall, presumably owing to catchment degradation. The latter period may be regarded as indicative for present conditions.

SR-3 Water resources modelling

The water resources modelling study has been based on MIKE BASIN, which is a tool for modelling and GIS analysis of river basin networks. The model describes the river network and the water allocation in terms of supplies, storages, withdrawals and diversions. Input to the model comprises time series of catchment runoff, reservoir operation, and prioritised water demands. Output comprises time series of flow in the main rivers, and the water allocated to various users. The model was set up with a time increment of 1 week.

Two calibration periods were applied: 1976-87, and 1987-98. The former illustrates the base conditions of the basin, at a time when the basin was less affected by regulation and land use intervention than it is today. The latter represents present conditions and the present state of development. With this starting point, three scenarios have been examined: (1) planned conditions, representing the presently planned regulation and developments; (2) potential conditions, representing the ultimate sustainable development of water resources; and (3) Nam Kok Reservoir, representing the planned conditions including the 3,000 Mm3 Nam Kok Reservoir. Scenarios (1) and (3) include the Kok-Ing-Nan diversion.

Results are presented as time series of discharges at the Fang-Kok, Lao-Kok and Kok-Mekong confluences, and as predicted satisfaction (and abstraction) over the year of the demand for irrigation water at selected locations. More results are available as data files and graphical presentations.

SR-4 Water pollution

Sources of wastewater have been divided into (i) Point sources: (i.a) Sewage discharges from towns; (i.b) factories; and (i.c) livestock (divided into species); and (ii) non-point sources: (ii.a) high-density urban areas; (ii.b) rural residential areas; (ii.c) agricultural areas, including paddy fields; (ii.d) orchards; (ii.e) forests; (ii.f) barren areas; (ii.g) wetlands; and (ii.h) water bodies. For each of these categories, and for each sub-basin in the project area, the present and future loadings have been estimated in detail in terms of BOD, nitrogen, phosphorus, and total coliform bacteria (where relevant).

Today, no part of the project area is sewered, and there are no treatment plants. The water consumption is estimated at 312 l/person/day in Chiang Rai municipality, and 200 l/person/day elsewhere.

In connection with the study, surface water samples were collected in April and November, 1999, at 9 locations on the main rivers in the project area. The samples have been analysed for 15 parameters as a basis for comparison with the NEB (1994) standard for 5 classes of surface water. Furthermore, older data (1991-98) are listed, as well as some analyses for heavy metals (from 1993 and 1995) are listed. In broad general, the water quality is characterised as fair or good.

The study describes present plans for sewage treatment, and recommends on practices and guidelines for management of sewage disposal from Chiang Rai, various districts, industry, livestock (the major source of pollutant loadings), and agriculture.

SR-5 Pollution load modelling

The objective of the pollution load modelling has been to conceptualise and analyse present and future pollution sources in the Basin. This has been done by the LOAD model. This model is in turn based on the ArcView GIS software. It calculates point sources and non-point sources of pollution, as generated by for example agriculture, industry and surface runoff. Input to the model comprises information about population, livestock, industries, land use, climate, vegetation, and sewage treatment and disposal. The routing of the pollutants is determined from a digital terrain model of the Basin. The decay (if any) of pollutants is taken into account.

SR-5 describes the model set-up, and the analysis of present and future pollution loads to rivers and streams in the Basin. The analyses comprise the area distribution and supply rates of BOD, nitrogen, phosphorus, and E. coli bacteria.

The results indicate that the surface water quality today is generally good, although there may be local and seasonal deteriorations that have not been resolved by the analysis. Disposal of untreated sewage from Chiang Rai is mentioned as a particular problem. Also, the predicted future water quality is characterised as good, although slightly below the present level. This is because the effects of increased loadings from a growing population and industrial expansion are not fully compensated by the improvements obtained by upland reforestation and water reclamation.

SR-6 Watershed management

Watershed management is a cornerstone of integrated water resources management. The state of the watersheds appear as the combined effect of natural conditions and human intervention.

The Kok River Basin, like almost all Thai watersheds, has been gradually degraded. It is characterised by stressed ecosystems, distorted water yields caused by deforestation, soil erosion, landslides and downstream sedimentation, and, in turn, reduced soil fertility caused by soil erosion and leaching of nutrients. Visible effects are lack of water in the dry season, lowering of the groundwater table, and increased floods in the rainy season.

The study describes the present state of the watersheds, and the character and effects of human interventions. Upland areas and mountains are exposed to (i) population pressure by growth and migration; (ii) degradation caused by deforestation and excessive slash-and-burn agriculture; and (iii) forest fires, which can be either natural or set alight for various reasons. Different types of upland cultivation are described.

The causes and effects of soil erosion are described in relation to (i) physiographic factors; (ii) the climate; (iii) the soil; and (iv) the land use. The average soil erosion in the project area is estimated at 6.4 t/ha/year (which reflects a classification as 'moderate'). In 30 percent of the project area, the soil erosion is classified as 'severe', and nearly 1 percent is classified as 'very severe', applying the OEPP (1995) criteria for soil erosion severity.

Recommendations on watershed management practices comprise (i) reforestation; and (ii) soil and water conservation. Reforestation is divided into headwater protection, commercial plantation, fruit cultivation and agro-forestry. Soil and water conservation comprises agronomic measures (compost, cover crops, crop rotation, and mulching), and mechanical measures (for example bench terraces, contour tillage, hedgerows, minimum or zero tillage, soil barriers, and water harvesting). Principles are outlined for implementation of such practices, which should build on the needs of the farmers and their knowledge about options and attainable benefits.

The report contains an attachment that describes management and sustainable development of agro-forestry systems for mountainous lands.

SR-7 Land use

The land use study aims at describing the present conditions in the project area, as a part of the basis for studies of the water cycle, the demand of water, and the pollution loads. Furthermore, the study

describes the potential for area expansion of cultivated areas. The findings provide indications of the future demand of water and of future pollution loads.

The study has been based on topographic army maps, soil and land use maps compiled by Land Development Department in 1992, and satellite imagery from March 1998. The information has been analysed by a GIS tool.

The soil suitability has been classified into 5 categories, characterised by the topography (slope) and the soil composition. The land use has been classified into 14 zones, depending on the actual land use.

It was found that 65 percent of the Basin is unsuited for cultivation because of steep slopes. There is no potential for expansion of the paddy cultivation area. A part of the area that is now used for upland crops is threatened by soil erosion. There is a need of protecting the remaining forest areas from fires and encroachment. Certain steep headwater areas should be reforested.

SR-8 Agriculture

Today and in the future, the agricultural sector is by far the largest water consumer in the basin. In consequence, the agricultural study forms an important part of the basis for assessment of the present and future demand of water resources, and its interaction with the environment.

The study describes present crops and cropping practices in each sub-basin. The following problems and constraints have been identified: (i) Low soil fertility (due to soil properties, poor management, or soil erosion); (ii) soil erosion in areas with steep slopes; (iii) use of land that is unsuited for cultivation; (iv) encroachment of forests causing soil erosion and high runoff; (v) lack of water; (vi) landholdings being too small, and lack of ownership; (vii) excessive use of fertilisers and pesticides; (viii) lack of knowledge about new technologies; (and (ix) top-down government policies that are not accepted by the target groups.

The following development options are suggested: (i) A partial replacement of paddy cultivation with cash crops; (ii) integrated farming; and (iii) development of fish ponds in areas that are suited for this purpose, such as the Lower Kok Basin.

SR-9 Fisheries

The fisheries study was based on compilation of data and review of information from previous surveys and publications. It forms a part of the basis for identification of development options and constraints.

The combined registrations from different surveys indicate the presence of 115 species in the Basin, belonging to 22 families of fishes and 1 family of freshwater prawn. There are several commercial species and exotic species, but no endemic, rare or endangered species. Several species migrate between the Kok Basin and the Mekong. The standing stock is estimated at 3-4 kg/rai, which is well below the 15 kg/rai found in productive rivers and reservoirs elsewhere in Thailand.

The study describes present fishing practices, which are simple and with a small yield. Capture fishery is typically practised as a side occupation, or for own consumption on a non-commercial basis. In the dry season, fishing is done by cast net, pole and line, and (illegally) by electro-fishing. In the wet season, bamboo traps are used as well. The non-commercial yield is 0.5 - 5 kg/person/day in the dry season and 5 - 6 kg/person/day in the wet season. The corresponding figures for commercial (side occupation) fishery are 2 - 6 and 10 - 15 kg/person/day.

The present trend is a degradation of the fish resource, possibly due to over-exploitation and pollution. Restoration requires targeted management and a number of regulatory measures, including prevention of over-exploitation and reduction of the pollution. There is scope for development of aquaculture, either as intensive or semi-intensive monocultures, or in connection with integrated farming.

SR-10 Solid waste

This study builds on several sources of information, notably the studies made in 1996 for the Environmental Investment Prioritisation and Action Plan for Chiang Rai and Chiang Mai Provinces,

respectively. Recommendations on long-term management strategies are taken from The Policy and Prospective Plan for National Environmental Enhancement and Conservation (1997-2016).

Two sources of solid waste are considered: Hospitals and private households. There are 194 hospitals and 263 clinics in the project area, with an estimated waste production of 0.36 kg per bed per day, or a total of 230 t/year of infectious solid waste (1998 data). The household production is estimated at 0.9 kg per person per day for Chiang Rai Municipality, and 0.5 kg per person per day elsewhere (1992/96 data). This gives a waste production in 1998 of 33,000 t/year, 43 percent of which is from Chiang Rai Municipality. The projected growth is largely confined to Chiang Rai Municipality, where the waste production may possibly escalate by a factor 22 from 1998 to 2020.

The study gives a summary of disposal practices and various related problems in each district. In many cases, it is difficult to locate suitable sites for waste disposal. In several cases, inappropriate operation causes pollution, or annoyances to people living nearby.

Since 1996, the garbage from Chiang Rai Municipality has been disposed on a controlled site, with a plastic membrane, geotextile, a drainage layer and drainage pipes for leachate collection. The waste is continuously covered by topsoil. Leachate is removed by evaporation or by overflow to a pond with an impermeable membrane. The disposal site will require expansion within a few years. A pilot project for waste separation was initiated in early 1999, but was discontinued due to lack of funds.

The study presents recommendations on the short-term and long-term management of domestic waste and infectious waste, respectively. The recommendations comprise structural as well as non-structural measures. Among several other measures, the public should be encouraged to Reduce, Reuse, Recycle and Repair the waste.

SR-11 Aquatic ecology

This study is based on information from literature, supplemented by ecological surveys at 9 stations in Kok, Fang and Lao Rivers in April and November 1999.

During the surveys, samples were collected of plankton, benthic fauna, and aquatic weeds. The results are presented and discussed.

The report gives an outline of an aquatic management plan. The potential for development of reservoir fisheries is mentioned. Among other targets, it is suggested that a minimum depth of 1 m should be maintained throughout the year in the rivers and their tributaries. Also, obviously, an appropriate water quality should be aimed at.

A separate chapter deals with wetland conservation. There are two particular wetlands in the project area, both of which are located in Chiang Rai Province: Nong Luang and Nong Wiang. Neither is in a pure natural state, but they serve as habitats for a variety of plants, fish species and other animals. Their ecosystems are not known in detail. No conservation measures have been imposed officially, but the local communities have regulated hunting and fisheries on a voluntary basis.

SR-12 Socio-economics

The socio-economic study provides data about the present and future population and economy of the Kok River Basin. The study is based on data from several agencies, notably NESDB (economic data) and Department of Local Administration (DLA) (population data). Information about socio-economic conditions has been drawn from the Kor-Chor-Chor 2 Kor survey by National Rural Development Committee in 1996.

The general economic growth in 1990-1995 was concentrated on manufacturing, construction, transport and communication, and wholesale and retail trade. Agriculture was stagnant, as well as the service sector. Industry is not visible in the statistics.

In 1997, the population in the project area was 206,848 persons in the Chiang Mai Province part, 36,974 persons in the Chiang Rai Municipality part, and 436,428 persons in the Chiang Rai Province

part outside the Municipality. A projection based on 1993-97 data points at a strong growth in Chiang Rai Municipality, and a slight growth elsewhere in the project area.

The following social indicators have been analysed: Population and households, education, labour migration (type of work, place and period), domestic supply of water (source and adequacy) and electricity, durability of house, and use of toilet. The following economic indicators have been analysed: Land holding, land use, rice cultivation area, dry season cropping, livestock/fishery/cottage industry, farmers' organisation and farmers' credit, and household income.

Areas of concern are (i) low education by national standards; (ii) poor health service by national standards; (iii) problems related to drugs, HIV and crime; and excessive migration, including cross-border migration.

A discussion is made of the implications of a water fee and a wastewater treatment charge.

Furthermore, the study describes the development of the tourism sector on the basis of data from TAT. In 1997, tourism generated an income of 5.4 bio. baht in Chiang Rai Province, and 20.9 bio. baht in Chiang Mai Province. There is a strong potential for a continued growth of this sector.

The study points at a potential for industrial development within fruit juice, processing of vegetables, orchids, ceramics, electronic parts, artificial flowers, jewellery, antiques, and milk and milk products. A recommendation is given on establishment of a university in Chiang Rai Province, and upgrading of the communication network.

SR-13 Community participation

This report describes the national institutional framework and the public administrative procedures.

A distinction is made between governmental administrative institutions and local self-governing bodies (or municipalities). The governmental administrative levels are province (changwat); district (amphoe); sub-district (tambon); and village (muban). The self-governing bodies are (1) the provincial capitals, which are classified as metropoles (nakhon) (like Chiang Mai) or towns (muang) (like Chiang Rai); and (2) the sub-districts (tambon). The provincial administrations are linked with the central administration in various ways, including administrative officers, who are employed under the provincial governor, but who serve as counterparts to the different ministries. The tambon administrations are new and are not yet consolidated. There are two types of informal, participatory institutions: The well-functioning people's irrigation systems, and the labour exchange system, which is now on a decline.

A total of 21 NGOs operate in Chiang Rai province (1999). They are involved in community development, including support to ethnic minorities, health promotion and AIDS alleviation, environmental preservation, and general social work.

In Chiang Rai province, there are somewhere around 145,000 hilltribe people and around 20,000 minority people (or 11 and 1.6 percent of the population, respectively) (1998 data). These people live mostly in the highlands.

The study gives an outline of mechanisms behind public awareness and attitudes, and types of conflicts of interest. It is evaluated that a positive attitude can be relied on towards integrated management of water resources and the environment. Recommendations are made on public consultations and institutional strengthening.

Appendix C
National planning goals and strategies

The following is an extract of Thailand's Eighth Economic and Social Development Plan (1997-2001). The English text has been downloaded from the Internet Website of NESDB.

PART VI : Natural resource and environmental management

The recent history of Thailand's development has seen huge amounts of natural resources being utilised, under inadequate and inappropriate management systems, in order to increase national income and upgrade living standards. While the benefits in terms of rapid economic growth are clear, a number of problems have accompanied them. Over-exploitation has resulted in unprecedented depletion and deterioration of Thailand's natural wealth, and has thus affected the Kingdom's economic stability. Competition for access to resources has given rise to social conflicts. Poor management of exploitation has led to an increase in the number of natural disasters. The far greater emphasis placed on the expansion of economic activity, with concomitant expansion of urban communities, than on environmental concerns has allowed pollution problems to develop to the point where they are hazardous to life and health.

In order that environments and natural resources can serve as factors contributing to sustainable development and better quality of life, it is vital for the Eighth Plan to incorporate the urgent conservation and rehabilitation of natural resources and to protect both urban and rural environments.

Local people and community organisations should be urged to play an increasingly active role in the management of natural resources and environments. Economic instruments should be used for controlling and supervising utilisation and management in this respect. Furthermore, restraint and greater efficiency should be promoted, so that natural resources can be used to the greatest possible advantage for the economy as a whole, while having the least possible environmental impact. Thailand should also play a greater role in international resource management at both regional and global levels.

Chapter 1: Objectives, targets and strategies

1 Objectives

In order that environments and natural resources are maintained in a condition in which they are of lasting benefit to the quality of life of the Thai people and to national development, the Eighth Plan sets out the following objectives for their management:

1.1 To ensure utilisation of natural resources is counter-balanced by rehabilitation and protection programmes.

1.2 To promote more effective management, involving the collaboration of various different sectors of society, so as to achieve greater balance in ecosystems and environments. Opportunities will be provided for local people and organisations to play a greater role in natural resource and environmental conservation in their own communities, with support from the public sector, academic experts, NGOs and business enterprises.

2 Targets

2.1 For enhancing the quality of life of individuals and communities:

(1) Rehabilitate and protect forest areas covering no less than 25 percent of the entire Kingdom, and demarcate reserve forest zones, within the period of the Eighth Plan.

(2) Give reserve forest status to no less than one million rai of mangrove forest by the end of the Eighth Plan period, in order to safeguard environmental balance and bio-diversity.

(3) Promote proper natural resource management systems for community forests so as to protect the environment and develop the quality of life of local people.

(4) Ensure water quality does not fall below 1996 standards in rivers, seas, coastal areas and all natural water resources, with particular emphasis on the lower Chao Phraya River, the Tha Chin River, pollution control zones and major tourist destinations. This will ensure conditions are appropriate to sustain aquatic life.

(5) Monitor and maintain air quality in cities and pollution control zones in line with national standards. Limit noise pollution in order to minimise damage to people's hearing.

(6) Upgrade the garbage collection capacity of municipality and sanitary districts, and promote safe disposal of hazardous waste.

(7) Promote proper and complete disposal of contaminated waste in both public and private hospitals.

2.2 For improving economic production:

(1) Reduce areas affected by soil erosion by no less than one million rai every year of the Eighth Plan period.

(2) Solve other soil problems which make land unusable for agriculture, such as soil salinity, soil acidity and lack of necessary micro- organisms, on no less than one million rai of land during the Eighth Plan period.

(3) Formulate a plan for the rehabilitation of Thailand's marine environments. This plan will focus on the conservation, rehabilitation and proper utilisation of natural marine resources and environments, particularly water quality, marine fauna, coral reefs, sea grass, and coastal areas.

3 Strategies for Natural Resource and Environmental Management

The Eighth Plan proposes the following major strategies to achieve the objectives and targets set for natural resource and environmental management:

3.1 Rehabilitation of natural resources and environments.

3.2 Promotion of the participation of local people and communities.

3.3 Proper management of natural resources and environments.

Chapter 2: Rehabilitation of natural resources and environments

The Eighth Plan proposes the following development guidelines for the rehabilitation natural resources and environments in order to promote balance in the ecosystem and upgrade quality of life for Thai people, and so that they can contribute towards sustainable national development:

1. Manage the Rehabilitation of Degraded and Abandoned Land, so as to increase agricultural output and minimise negative environmental impact. Attention should be given to former mining sites,

former shrimp ponds and farm lands abandoned because of unfavourable soil conditions, such as soil salinity, soil acidity and coastal-type soils. Specific guidelines to be followed are:

1.1 Promote the conservation of land and water resources, including the improvement of soil quality by organic methods. Emphasis should be placed on the promotion of accepted and transferable farming practices, such as integrated farming to replace monoculture, shifting from chemical to organic fertilisers, and terrace farming.

1.2 Introduce new farming practices in land reform zones, abandoned shrimp ponds and abandoned mining sites, by providing the necessary knowledge and training, financial support and appropriate technology. This will enable farmers to earn enough income to support themselves in the long term and so stop them abandoning rural areas, and induce them to carry on rehabilitating the land and not utilise it for non- farming activities.

2. Reduce the Volume and Distribution of Pollution in Local Environments, by proper management of various types of pollution, such as community and industrial wastewater, air pollution, industrial waste and hazardous substances so they do not pose a threat to public health and living conditions.

2.1 Reduce and control water pollution from community activities and agricultural and industrial production.

(1) Formulate pollution control plans for 25 major river basins around the country.

(2) Designate guidelines and emergency operational plans to prevent the spread of pollution which affects the quality of terrestrial water resources and of marine waters.

2.2 Reduce the volume of air pollution on industrial estates and in traffic-congested areas, particularly the volume of sulphurous compounds in diesel exhaust, black smoke and dust entering the atmosphere.

(1) Regulate vehicle standards and improve the quality of petroleum-derived fuels – by, for example, reducing exclusive gravity – and reduce sulphurous substances in diesel oil. In addition, the quality of oil should be brought in line with pollution reduction measures and relevant authorities should carry out feasibility studies for raising vehicle standards.

(2) Identify pollution sources which need stricter measures to control the emission of air pollution in order to reach approved standards.

2.3 Waste and garbage disposal.

(1) Encourage provincial authorities to seek appropriate plots to serve as long-term sites for land-fill garbage disposal, and to designate appropriate areas in urban plans.

(2) Establish appropriate criteria for garbage and waste management, which cover the processes of collection, transportation and hygienic disposal. In addition, emphasis should be placed on the processes of reducing, reusing and recycling waste.

2.4 Reduce and control sources of hazardous substances, by subjecting factories that produce or utilise hazardous substances in large volumes to environmental impact and risk assessments and strict guidelines on control of the substances.

3. Support the Establishment of Comprehensive Waste Treatment and Disposal, comprising comprehensive wastewater treatment and garbage disposal.

3.1 Encourage long-term investment in comprehensive wastewater treatment and garbage disposal facilities in regional economic centres, namely the five provinces of the Bangkok Metropolitan Region, the eastern coastal areas of Chon Buri and Rayong provinces and other coastal cities and tourist destinations.

3.2 Promote the establishment of centralised waste disposal facilities and contaminated garbage disposal centres for the joint use of communities and neighbouring provinces.

4. Promote the development of waste disposal technology and green technologies to be applied to the production process, which will minimise environmental impact. Such technologies will be prototypes that may be put into commercial production. Also, promote analysis and evaluation of technology for appropriate environmental management that can be transferred for effective application.

Chapter 3: Promotion of Popular Participation in Natural Resource and Environmental Management

These development guidelines seek to encourage greater participation by local people and communities in more effective and systematic management of natural resources. They are:**1. Expand the Public Sector's Role in Promoting Popular Participation in Natural Resource and Environmental Management, by:**

1.1 Changing the attitudes of government officials and upgrading the capacity of relevant government agencies for effective cooperation with and facilitation of, local communities in conservation of natural resources and environments in such a way that they will be of real benefit to those communities.

1.2 Conducting public relations campaigns to raise public awareness of the consequences of deteriorating natural resources and environment. The public should, moreover, cooperate in the monitoring and alleviation of problems affecting natural resources and environments.

2. Develop Information Networks on Natural Resource and Environmental Conservation, and disseminate useful data to the public, recognising the equal right of access to information of all parties.

3. Provide More Opportunities for Local Communities and People to Participate Actively in Natural Resource and Environmental Management, by:

3.1 Providing opportunities for people and communities to participate in decision-making about, monitoring and evaluation of public development projects likely to have an impact on natural resources and the environment. The government should facilitate continual public discussion at every step of those projects: initiation, preparation and implementation.

3.2 Enacting the Community Forest Legislation, in a form which is acceptable to all parties concerned, so that local people will have legal rights to protect and utilise community forests.

3.3 Providing legal guarantees of the rights of local communities and small fishermen to participate in coastal resource management, as well as the conservation, rehabilitation and maintenance of mangrove forests, sea grass and coral reefs, to ensure sustainable use of coastal resources, especially those related to the fishing industry.

3.4 Encouraging local communities and organisations to conduct eco-tourism within their localities for the benefit of community economies. They should learn the processes of project formulation and planning in order to obtain financial assistance from the government budget, natural resource conservation funds or other sources.

Chapter 4: Improving Natural Resource and Environmental Management

Emphasis will be placed on a thorough and systematic approach and the provision of appropriate legislation, so as to achieve effective management of natural resources and environments. The Eighth Plan proposes the following development guidelines:

1. Establish Systematic Management of Water Resources, especially at river basin level, including the provision of clean drinking water and supervision of water quality, pollution control and drainage. This will include:

1.1 Organising supervisory and coordinating mechanisms for the development of water resources at both national and river basin levels, so as to ensure consistency in and continuity in the work of all related agencies.

1.2 With the participation of all parties concerned, setting up appropriate systems at various levels for the allocation of water resources between the various types of water consumer, based on the principles of necessity, priority and fairness.

1.3 Collecting fees for raw water from industrial and agricultural producers and from domestic consumers. The pricing structure for domestic consumption and industrial production will be adjusted to properly reflect the actual costs of procurement, production, distribution and wastewater treatment.

1.4 Improving the transmission and allocation systems for both irrigation and domestic consumption in communities, so as to minimise wastage of clean water through leaks.

1.5 Conduct public information campaigns to promote thrifty and effective use of water, encourage the utilisation of water-saving devices and the re-use of cooling water and treated wastewater in some industrial activities.

2. Coordinate Land Use Policy and Management Consistent with and Appropriate for the Development Potential of Each Area, which ensure fair distribution of benefits to all local people and communities.

2.1 Mark out specific land use zones both inside and outside national reserve forest, taking into account soil characteristics in those areas. Also, coastal land use planning should take into account local economic and social conditions and the impact on coastal environment conservation. The country's irrigation zones should be preserved so as to enhance agricultural production. Laws, rules, regulations and incentive schemes should all be considered as ways of ensuring that this zoning is respected.

2.2 Designate and demarcate local ecosystem zones, taking into account any cultural and traditional diversity within the zones so that local people's existing lifestyles can contribute to the sustainable management of natural resources and the environment.

2.3 Adjust the administration of the current agricultural land reform system so as to resolve the problems of landless farmers, both by issuing land rights documents and establishing a system for monitoring and inspecting utilisation and reforms of public land.

3. Ensure Sound Management of Community Environments and Green Areas, by setting out clearer policies and implementation guidelines for the conservation of natural environments, green areas, vacant plots and urban public parks. The respective proportions of available land devoted to these sites, the number of people and rate of growth in urban communities, and landscape characteristics should all be major considerations.

4. Conserve Natural and Heritage Sites, by formulating managerial and conservation guidelines; for example the registration and declaration of areas of natural beauty and heritage sites. The development potential of these areas should be upgraded in such a way as to enhance economic activity and promote eco-tourism.

5. Promote an Holistic, Systematic Approach to Natural Resource Management

5.1 Expedite surveys and assess existing mineral and natural resources nationwide, focusing on the impacts of their exploitation on the local eco-system, preserve mineral resources within conservation zones for future use.

5.2 Encourage more effective use of mineral resources under sound conservation methods, taking account of sound balance in natural resources and environments, and coordinating it with the utilisation of other natural resources.

6. Improve Systems for the Prevention and Relief of Hardship and Suffering Caused by Natural Disasters

6.1 Upgrade the efficiency of those agencies responsible for prevention of and rehabilitation from natural disasters, with greater emphasis on early warning and prevention of natural disasters.

6.2 Establish area-level coordination systems for the different types of natural disaster, making effective use of existing management and prevention mechanisms.

6.3 Get regional and provincial authorities to draw up maps showing areas prone to natural disasters to be used as resources in early warning, prevention and containment of natural disasters.

6.4 Establish measures for public participation in self defence against natural disasters, enforce rules and regulations and provide training to raise the public's knowledge about natural disasters.

7. Improve the Efficiency of Public Agencies involved in natural resource management, including the control and resolution of environmental problems

7.1 Change methods and approaches in planning and budgeting for natural resource management programmes away from departmental considerations to areas like provincial groupings, local conditions and the potential for development of each type of natural resource. Operational procedures and networks should involve multi-lateral cooperation, united by a common objective.

7.2 Develop and improve the efficiency of monitoring, supervision and control systems for natural resources, by encouraging the owners of relevant enterprises to monitor, supervise and record pollution problems. In this way a thoroughgoing surveillance system can be created.

7.3 Advocate legislation to prohibit fishing methods destructive to coastal eco-systems, particularly the use of push-nets and trawling, and urge fishermen to switch to more sustainable methods.

7.4 Supervise and control the decentralisation from urban to rural areas of industrial activities likely to have an impact on local environments, while looking after the health of factory workers and those living in nearby communities.

7.5 Draft and amend rules and regulations on environmental protection to bring them in line with current pollution problems and to minimise damage to the environment, for example by introducing fees for garbage collection when necessary and introducing an insurance system for the disposal of hazardous waste.

8. Enlarge the Kingdom's Role in International Cooperation on Environmental Protection, by making explicit statements of Thailand's stance on environmental policy in international fora. Relevant organisations and personnel should be equipped to play a greater role in international environmental negotiations at both bi-lateral and multi-lateral levels, in order to protect the national benefit. Also, emphasis should be placed on technical cooperation to address international problems and concerns, such as depletion of the ozone layer and global warming.

Appendix D
Glossary

Agenda 21 (Agenda for the 21st Century) was passed by the UN Conference on Environment and Development (UNCED) in Rio de Janeiro, 1992. Agenda 21 is a global programme that committed 118 countries to environmental restoration, preservation and social development. Their aims were to meet the challenge of global warming, pollution, biodiversity and the inter-related social problems of poverty, health and population. Article 18.9 of Agenda 21 deals with integrated water resources management: *'Integrated water resources management, including the integration of land- and water-related aspects, should be carried out at the level of the catchment basin or sub-basin. Four principal objectives should be pursued, as follows: (a) To promote a dynamic, interactive, iterative and multisectoral approach to water resources management, including the identification and protection of potential sources of freshwater supply, that integrates technological, socio-economic, environmental and human health considerations; (b) To plan for the sustainable and rational utilisation, protection, conservation and management of water resources based on community needs and priorities within the framework of national economic development policy; (c) To design, implement and evaluate projects and programmes that are both economically efficient and socially appropriate within clearly defined strategies, based on an approach of full public participation, including that of women, youth, indigenous people and local communities in water management policy-making and decision-making; (d) To identify and strengthen or develop, as required, in particular in developing countries, the appropriate institutional, legal and financial mechanisms to ensure that water policy and its implementation are a catalyst for sustainable social progress and economic growth.'*

Alluvial: Formed by river sediments. An alluvial river flows in a landscape formed by its own sediments

Analysis (of data): Processing, involving a sometimes comprehensive transformation and interpretation, in order to arrive at some desired knowledge. Data analysis is often carried out stage-wise and in different contexts. In general, it involves both hidden and explicit assumptions about the relation between primary data and final results. Such assumptions can affect both the accuracy and the validity of the results. A suitable quality is supported by an adequate transparency of the analysis

Basic minimum needs: These can comprise food and water, shelter, primary education, vital health care, and personal integrity. In Thailand, Department of Rural Development has defined 39 indicators of basic minimum needs, which are applied for monitoring of social development

Benthic: Growing/living on or in the river bed

BOD: Biological oxygen demand, meaning the amount of oxygen required for biological mineralisation of organic (or inorganic) degradable matter in sewage or in a natural watercourse. This indirect unit is widely applied because it is easy to measure in the laboratory for samples that contain a variety of (perhaps unknown) compounds. BOD is harmless in itself, but excessive supplies can cause oxygen depletion. BOD is expressed as a mass (g or kg oxygen), a concentration (mg oxygen per litre), or as a supply rate (oxygen mass per time unit)

Catchment area (or drainage area, or watershed): An area that drains through a specific river cross-section

Consistency (of data): Compliance between the quality of different data sets, produced by different methods, or at different places, or at different times

Cost (of water): Can be divided into operation and maintenance costs of supply and distribution system, capital costs, opportunity costs, external costs, and environmental costs. (External costs are consequential costs or benefits, or simply opportunity costs in a wider sense). See also *valuation of water*

Crop intensity: In the present study, the crop intensity (for a given cultivated area) has been taken as 100 percent (representing the wet season) + xx percent (representing the part of the area that is actually cultivated in the dry season)

Crop requirement (of water): The amount of water required for cultivation of one crop, as available to the crop in the field where it grows (supplied by rainfall and irrigation). The crop requirement can be estimated as the potential evapotranspiration multiplied by a crop coefficient (reflecting the crop species and the stage in its cultivation cycle). Often expressed in mm per crop

Demand (of water): The amount of water required for a given purpose, for example litre per person per day, or mm per crop. The demand can be present or future, and it can be actual (i.e. related to an available infrastructure) or potential (assuming full infrastructural development and no water shortage). The serviceable (part of the) demand is limited both by infrastructure and water availability

Demand satisfaction (of water for irrigation): The water that is available (at the intake from the river), in percent of the withdrawal demand, at a given time for a given crop and a given cultivation routine. Today, in the Kok River Basin, the demand satisfaction is lowest in July, because the cultivation practices are in general accordance with the water availability

Demonstration projects are intended for confirming the site-specific, practical value of new technology (for example new crops or new cultivation routines)

Development objective (or overall objective, or development goal, or mission): A desired future situation, which is supported by a plan (or programme or project) that is targeted towards it. The plan (or programme or project) cannot in itself assure achievement of the development objective - this is subject to a number of assumptions on related developments that are outside the control of the plan (or programme or project). Some authors recommend that only one development objective be applied from case to case, and that it be specified in time, space and quantity

Discharge: Net flow (or net sediment transport) through a fixed cross-section of a river

Driving force: A circumstance that has a major (positive or negative) influence on pursuance of a set of planning goals. It can appear as a trend, a cycle, an analogy, or an event. A driving force cannot be fully controlled by the participants in the planning process. A driving force can be unpredictable, or not well understood, or even unknown

Dry season (in the present study): December through May

Dublin Principles (from *International Conference of Water and the Environment, Dublin 1992):* (1) Freshwater is a finite and vulnerable resource, essential to sustain life, development and the environment; (2) water development and management should be based on a participatory approach, involving users, planners and policy-makers at all levels; (3) women play a central role in the provision, management and safeguarding of water; (4) water has an economic value in all its competing uses and should be recognised as an economic good

Ecological demand (of streamflow): The minimum flow that is required for preventing significant (medium- or long-term) flow-related ecological damage. The ecological demand varies along the river and over the year. Sometimes, the waterlevel can be critical, rather that the flow rate

Effective rainfall: The part of the direct rainfall that can actually be used by the crop. For rice, the effective rainfall equals the direct rainfall. For other crops, the effective rainfall is the direct rainfall minus surface runoff minus seepage to the underground (below the root zone)

Eutrophication: Excessive supply of nutrients, resulting in a high primary production. Eutrophication can have negative ecological effects, such as large fluctuations of dissolved oxygen between night and day, or damage to benthic vegetation due to shading by algae

Evapotranspiration is the loss of water from the ground to the atmosphere by evaporation and by transpiration (of plants). The rate is determined by the energy supply (by sunlight radiation), the wind speed, and the moisture of the air. Potential evapotranspiration is the capacity of the atmosphere to remove water from the ground, if water is available without constraints

Fish yield: In reservoirs: 100 kg/ha/year (large and medium size reservoirs), 250-500 kg/ha/year (small reservoirs); cage culture in canals: 100-150 kg/year/m² of cage, or 50-60 tonnes/year/km of (primary) canal; rice paddy production: 100-200 kg/ha/year; flood plain yield 50 kg/ha/year; integrated farming systems: up to 5-15,000 kg/ha/year (based on experience from China)

Flow: Volume transport per time unit (for example through a cross-section of a river)

Gauging: Measuring at a fixed point; a gauge is a measuring device (e.g. for water-level)

Global Water Partnership (GWP): An international network (established in 1996) of organisations involved in integrated water resources management: Governments of developing as well as developed countries, UN agencies, multilateral banks, professional associations, research organisations, the private sector and NGOs. The activities of GWP build on the Dublin Principles

Goal: Same as *objective*

Greater Mekong Sub-region (GMS): Cambodia, Yunnan Province of China, Myanmar, Laos, Thailand and Vietnam. In terms of area and population, the GMS is much larger than the Mekong River Basin, because it comprises the entire countries (or province in the case of Yunnan), and not only the parts that are located in the Mekong drainage area

Green taxes: Taxes that are levied in order to regulate consumption, production or behaviour that affects pollution or utilisation of sparse resources. They aim at a better concordance between actual, immediate, direct (market) costs and total, long-term social costs (including public health, environmental impact and preservation of important resources). The can serve a fiscal purpose as well, or they can be fiscally neutral, for example if the green taxes are used for subsidies of the same sector. Green taxes can for example be levied on cars, fuel, energy, pesticides, fertilisers, water, sewage discharges, and carbondioxide emissions

Groundwater recharge: The replenishment of groundwater with surface water

Holistic (view, analysis): (A view, analysis) of a system as a whole (rather than selected elements, states, or processes)

Hydrograph: A time series of water-levels at a fixed location (either measured or calculated by a model)

Hydrology: The study of the water cycle

Immediate objective: The intended situation that is achieved as the direct result of orderly implementation of a plan (or programme or project). The immediate objective is the result of a number of outputs, which, between them, are necessary and adequate for achieving the immediate objective. Some authors recommend a maximum of 3 immediate objectives, and that these are specified in time, space, quantity, quality and target group

Incremental planning: Planning in (small) steps, for example when development goals are unclear, uncertain, or in conflict with each other

Infiltration: Loss of surface water by absorption and seepage into the ground. Infiltration capacity is the ability of the soil to absorb surface water. Deep infiltration is seepage from the root zone to the underlying soil layers, whereby the water becomes lost to the vegetation

Integrated farming: An area-intensive and labour-intensive combination of different parallel productions, like a fish pond, paddy, fruit trees, livestock, cash crops and vegetables. Integrated farming can give yields that highly exceed monoculture yields

Integrated water resources management (as defined by Global Water Partnership): A process which promotes the co-ordinated development and management of water, land and related resources, in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems

Irreversible: That cannot be changed back to the original state

Irrigable area: The area that can actually be irrigated with a specific (present or future) infrastructure (disregarding the finite availability of water)

Irrigation efficiency: The ratio between the crop water requirement and the irrigation requirement. In the present study, a value of 0.3 has been applied

Irrigation requirement (or withdrawal demand for irrigation): The required gross amount of water needed to be withdrawn (from the river) to cultivate a crop, often expressed in mm per crop. It equals the crop requirement, minus direct rainfall, plus the return flow from the field to the river, plus miscellaneous losses (distribution, conveyance, and infiltration out of the root zone)

Kor-Chor-Chor 2 Kor: A socio-economic data base compiled by National Rural Development Committee in 1996

Mekong River Commission (MRC) is a permanent regional body formed by Cambodia, Laos, Thailand and Vietnam. Its mandate is laid down in the 'Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin', or the 'Mekong Agreement', which was signed by the member countries in Chiang Rai on April 5, 1995. The Mekong Agreement includes articles on intra-basin and inter-basin use of the Mekong River in the dry and the wet season, and charges the MRC Joint Committee with preparing and proposing rules for water utilisation and inter-basin diversions. The predecessor of MRC, the 'Committee for the Coordination of Investigations of the Lower Mekong Basin', was established by the same countries on 17 September 1957

Model: (i) A simplified description of a part of reality; (ii) a structure of selected, assumed relations within a system (used for analysis of that system); (iii) a computer programme for analysis of natural phenomena

Morphology (of a landscape or a river): (1) its shape, (2) the study of states, processes and effects related to the shape

Nutrients (in a special meaning often applied within aquatic ecology): Dissolved salts that are essential for primary production in the aquatic environment. They are supplied by sewage or by agricultural runoff. A nutrient can control the rate of the primary production, if all other necessities (like other nutrients, light and carbon) are plentiful. Key nutrients are nitrogen and phosphorus. In the aquatic environment, nutrients appear in nature in low concentrations, but they can cause eutrophication and ecological damage if supplied in large quantities. Fertilisers are pure nutrients, and their residues can contaminate streams, rivers and lakes, if carried by overland flow or irrigation tailwater

Objective (1) (same as goal): Please refer to *development objective* or *immediate objective;* (2) (about criteria) (opposite of subjective): Clear, unambiguous, undistorted by arbitrary judgement

Operational, (1) (about criteria): Measurable, or otherwise objectively verifiable; (2) (about strategies): Clear, objectively implementable

Opportunity costs: The costs of one course of action, relative to the 'best' course of action. In a wider sense, the implications of one course of action, relative to a strategy that is 'ideal in terms of benefits'. In development projects, the opportunity costs can reflect the time lag from when a new technology emerges and until it becomes available to the target group. There is often an opportunity cost related to doing nothing

Opportunity window: A shift between *'technological regimes',* represented by access to a new technology, which can change the balance between for example centralised/decentralised development, or large-scale/small-scale development. The new technologies can for example be within agriculture, food processing, information technology, etc. One example is high-yield varieties of rice. The outcome need not be positive in all respects

Overland flow: The flow of water on the ground from precipitation to streams located at lower elevations. Occurs when the infiltration capacity of an area soil has been exceeded

Pelagic: Living in the free water column

Photosynthesis: The primary production (by plants, algae and some bacteria) of simple carbohydrates (such as sugar), normally from (inorganic) carbondioxide, and using energy supplied by the sun

Phytoplankton: Photosynthetic aquatic microorganisms (algae)

Pilot projects are intended for testing solutions to new and complex problems. They are typically small-scale, implemented in a short time, and with low costs

Precipitation: Rainfall and snow reaching the ground

Pollution: Release to the environment of a substance that can harm it

Quality: The compliance between an actual and a desired property (or set of properties) (for example an actual biodiversity as compared with a desired biodiversity)

Reference: A basis for comparison (for example 'present situation', or 'future situation without intervention'

River basin: The catchment area of a river

Rice yield (1997): Cambodia 1.5 t/ha (steady), Lao 2.7 t/ha (increasing), Thailand 2.3 t/ha (steady), Vietnam 3.8 t/ha (increasing); world average (1994) 3.7 t/ha

Seepage: Slow movement of water in the ground, or from the ground to the surface

Scenario: A hypothetical (but preferably consistent) combination of events and physical conditions, describing a possible future situation

Sector planning: Planning for a specific income generation, like agriculture, industry, fisheries, tourism, hydropower, etc.

Simulation: A specific reproduction, by numerical modelling, of the time variation of a natural system

Stakeholder: A person, group or institution that has a particular interest in an activity, project, programme or policy. This includes both intended beneficiaries and intermediaries, winners and losers, and those involved and/or excluded from the decision-making process. A key stakeholder is one who can significantly influence or who is otherwise important to the success of the activity, project, programme or policy

Strategy (same as action plan): A plan for how to reach a goal

Sustainability (1) (according to the UN World Commission on Environment and Development, the *'Brundtland Commission',* as reported in *'Our Common Future'):* Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs; (2) environmental sustainability means avoidance of irreversible conflicts with a desired state of the environment (for example groundwater being suited for drinking); (3) a donor agency consider a project as sustainable if it provides adequate benefits to the target group for a certain period of time (preferably many years) after project completion

Synergy: Mutual stimulation or amplification of two parallel processes, whereby their joint (positive or negative) effect becomes larger than the sum of the effects of each individual process. The existence of synergy effects is a part of the background for integrated planning

Thematic planning: Planning for a specific topic that affects different sectors, like water resources, the environment, education, public health, poverty alleviation, etc.

Trend (in a data record): A gradual change of the general level of values

Valuation (of water): The direct value to users of water can be expressed in terms of crop yield, production output, generated energy, environmental quality, or money, expressed per unit of water, or as a function of quantity. The total value of water is the direct value, plus a net benefit of return flows, benefits from indirect uses, a societal value, and an intrinsic value (reflecting access, ownership, amenity, etc). See also *cost of water*

Water pricing: A tool for management of water allocation between areas, sectors and individual users, assuming that an 'optimal' allocation (or just a sustainable allocation) can be determined on the basis of a water price that reflects the full costs (and hereby the full value) of water (for example, in economic theory, by charging the full costs and relying on free market mechanisms for allocation). Such a strategy can improve water efficiencies and reduce waste of water. It will often give preference to industrial allocations rather than irrigation. See *valuation* and *cost of water*

Wetland: An area that (for natural reasons) is covered by water in at least a part of the year. A wetland can represent a special ecological habitat, sometimes with a high biodiversity, and can serve as a fish breeding ground

Wet season (in the present study): June through November

Withdrawal demand: The required amount of water needed to be withdrawn (from the river) for a given purpose

Appendix E
Project ideas

Notes

The project ideas are listed in random order. They are independent from each other

Budgets are rather speculative and serve as loose indications only

Applied exchange rate: 1 USD = 35 baht

Ecological textbook

Justification:	General, public support to management of water resources and natural resources is necessary for success. The support is subject to knowledge about basic cause-effect relationships
Objective:	To achieve a broad increase of environmental awareness
Scope:	Preparation of a popular textbook (at primary school level) about the water cycle of the Kok River Basin, illustrating the socio-economic and environmental significance of water. The scope includes publication and free distribution to all primary schools in the area
Implementation:	OEPP, Ministry of Education, NGOs, universities
Budget:	12.0 mio. baht (343,000 USD)

Wetlands biodiversity

Justification:	Today's knowledge is incomplete about the biodiversity of the wetlands in the Basin. The possibility exists that their socio-economic and ecological significance is under-rated
Objective:	To supply knowledge about the socio-economic and ecological significance of the wetlands, and options and constraints to preservation and development
Scope:	Mapping of the biodiversity of the Nong Wiang wetlands and the area around the Kok-Mekong confluence, and study of the present relations with human activities. (Nong Luang is omitted because a study is already in progress in that area)
Implementation:	OEPP, NGOs, universities
Budget:	5 mio. baht (143,000 USD)

Highlands biodiversity

Justification:	The highlands play a key role in the long-term development of water and natural resources. Knowledge is required about the dynamic impact of current reforestation programmes, as a basis for consolidation and future management
Objective:	To supply knowledge about the present biodiversity, development trends, and management options and constraints
Scope:	Mapping of the biodiversity of the highlands of the Kok River Basin, exemplified by typical areas, and study of the present relations with human activities, including socio-economic options and constraints to reforestation efforts
Implementation:	OEPP, RFD, NGOs, universities
Budget:	1.5 mio. baht (43,000 USD)

Groundwater potential and management study

Justification:	Today, knowledge is incomplete about the groundwater potential, and about possible irreversible pollution threats. The possibility exists that groundwater will appear as a critical resource some time in the future
Objectives:	(1) To map the groundwater resource and quality; (2) to identify key threats to its preservation, and related mitigation measures and management strategies
Scope:	Mapping of resources (quantities and quality) in selected areas, including the area around Chiang Rai. Drilling of a number of observation wells, with test pumping and water quality analysis, including tracers of pollutants. Assessment of potential pollution risks. Preparation of draft regulations and management practices for groundwater conservation and utilisation. Can be divided into several phases and components
Implementation:	Department of Mineral Resources, Ministry of Industry; Provincial Waterworks Authority; OEPP
Budget:	50 mio. baht (1,430,000 USD)

Ecological demand of surface water

Justification:	The ecological demand of surface water is an important indicator in integrated water resources management. It is one (among several other) determinants of the available resources. Today's knowledge is far from complete about the magnitude of the ecological demand, and about its seasonal variation and distribution across the river basin. This uncertainty is unfortunate, because an over-estimation can lead to 'waste' of sparse surface water, while an under-estimation can lead to irreversible ecological damage
Objectives:	To provide a good estimate of the ecological demand, as distributed in time and space, as a reference for a sustainable allocation of water resources
Scope:	Comparison between actual/historical flow distribution and observed or potential ecological effects. Assessment of governing cause-effect relationships and their conceptualisation into simple, operational criteria for streamflow and/or water level at control sections across the river basin. Assessment of uncertainties and confidence intervals
Implementation:	OEPP
Budget:	5 mio. baht (143,000 USD)

Agricultural demo projects

Justification:	Agriculture is a key sector of the economy of Kok River Basin, but its development is impeded by water shortage and low earnings from traditional products. Thailand possesses a unique expertise within agricultural diversification, which can form the basis for implementation in the Kok River Basin on a pilot scale
Objective:	To identify, by targeted experiments, options for increasing the output value per unit of water
Scope:	To implement, on a fully subsidised pilot basis, untraditional supplementary high-value crops (such as orchids, other flowers, medical herbs, exotic spices, etc). Study of potential and constraints to full-scale commercial production, including quality certification and marketing. Estimation of opportunity costs, and identification of risks and adverse side effects. The project can be divided into several separate or subsequent activities
Implementation:	MoA, TISTR, universities; possibly, coordination with ASP
Budget:	1.5 mio. baht (43,000 USD) per activity

Pesticides and fertilisers

Justification:	Elsewhere in Thailand and in the Mekong Basin, the use of pesticides and fertilisers has been identified as a serious threat to the environment and to the public health
Objective:	To supply knowledge about present practices and development trends, as a basis for management and mitigation
Scope:	Survey of the present use of pesticides and fertilisers for different purposes. Evaluation of development trends, both on the demand and the supply side. Identification of scope for improvement of practices and constraints to implementation. Recommendations on management strategies
Implementation:	MoA, OEPP, universities; possibly, coordination with ASP
Budget:	1.2 mio. baht (34,000 USD)

State-of-the-environment report

Justification:	Effective resource management requires, among many other things, a baseline reference and a set of valid, operational indicators of positive and negative trends
Objective:	To support the management of water resources and natural resources by providing a set of indicators and a reference for development
Scope:	Identification of operational socio-economic and environmental (and water resources) indicators that are suited (valid and practical) for application in the Kok River Basin. Mapping of these indicators, analysis, and preparation of a 'state-of-the-environment' report (as a reference for monitoring)
Implementation:	OEPP, universities, Chiang Rai Province
Budget:	4 mio. baht (114,000 USD)

Drought mitigation plan

Justification:	The socioeconomic and environmental impact of droughts can be severe, particularly in case of several successive dry years. The socioeconomic damage may increase in connection with new crops, which are introduced in order to save water and increase earnings, but which are more risky. A general preparedness and a smooth inter-agency coordination of various timely mitigation measures can be a small, but valuable step towards reducing the negative effects
Objective:	Achievement of a high level of drought preparedness, and capacity to make and implement the right decisions at the right time
Scope:	Identification of socioeconomic and environmental needs and options. Analysis of bottlenecks and other constraints related to communication flow and authority. Recommendations on drought monitoring, mitigation strategies, and inter-agency liaison
Implementation:	Ministry of Agriculture and Cooperatives, OEPP, provincial administrations
Budget:	4 mio. baht (114,000 USD)

Tourism and the environment

Justification:	Tourism plays an important role in the economy of the Kok River Basin, and has a large scope for continued development. There are numerous positive and negative relations between tourism and the environment
Objective:	To provide a part of the basis for a continued, environmentally sustainable tourism development
Scope:	Mapping and analysis of relations between tourism and the environment in the Kok River Basin, identification of risks and 'hot spots', and recommendations on harmonised development strategies
Implementation:	OEPP and Tourism Authority of Thailand
Budget:	2.0 mio. baht (57,000 USD)

Agricultural theme park

Justification:	An agricultural theme park can serve educational and awareness-building purposes, and might become a tourist attraction at the same time. It would generate a number of new jobs outside of urban areas, and might contribute to preservation of a part of the cultural heritage of the region
Objective:	To establish a theme park that demonstrates traditional northern Thai agricultural practices, including practices of the recent past
Scope:	The theme park should appear as an active open-air museum. It could show actual cultivation of paddy and other crops, livestock, related food processing, and handicrafts. Apart from fields and village homes, there may be exhibitions, a restaurant and a souvenir shop. There might be a provision for school classes (and perhaps tourists) to live in the park for a couple of days. Emphasis should be given to ordinary, traditional technologies. Implementation could be stagewise
Implementation:	Private investor(s), Chiang Rai Province, and Tourism Authority of Thailand
Budget:	2.0 mio. baht (57,000 USD) (feasibility study and draft project plan only)

Essay/drawing contest

Justification:	Environmental awareness should be built from an early age. Today, knowledge about environmental cause-effect relationships is officially included in the school curriculum at all levels. The efforts deserve support in all ways
Objective:	To provide a small step towards higher awareness of environmental preservation and the value of water resources
Scope:	A friendly essay and/or drawing contest, targeting primary and/or secondary school students, with a subject related to the value of water, or a good environment. 'Official' diplomas to all contestants, and reasonable prices to the winners. Prices may be privately sponsored. An award ceremony suited for press coverage
Implementation:	DEQP, OEPP, Ministry of Education, Chiang Rai Province, with private sponsor(s)
Budget:	0.2 mio. baht (5,700 USD)

Other ideas

- A new solid waste separation project, building on the (not fully positive) experience from Chiang Rai
- Aquaculture demonstration project(s), in collaboration with Chiang Rai Freshwater Fisheries Station
- Agroforestry pilot projects or demonstration projects